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SPINY ANIMALS.

By R. LYDEKKER, B.A. Cantab.

IN our article on "Moles and their Like," published in the May number of KNOWLEDGE, it was shown how the adaptation to the necessities of a particular mode of life has produced a marked general external resemblance in certain burrowing mammals belonging to several more or less completely distinct groups. We now propose to point out the resemblances existing between certain other members of the same class of animals, owing to the assumption of a protective coat of spines. Although this resemblance is in some instances not so striking as among the creatures noticed in our previous article, yet it is quite sufficient to have obscured in popular estimation the real affinities of some of the spine-bearing mammals, as it is by no means uncommon to hear the hedgehog spoken of as the "British porcupine," while certain Madagascar spiny mammals are frequently alluded to as hedgehogs, and the Australian echidna is commonly alluded to as a porcupine. Moreover, the names "sea urchins" and "sea hedgehogs," applied to animals belonging to totally different classes, shows the important estimation held by spines in popular zoology. It is almost superfluous to add that the acquisition of the coat of spines in all the mammals here alluded to is solely for the purpose of protection; and how sufficient is this protection in most cases, is evident to all who have seen how the hedgehog, when rolled up, sets most dogs at defiance. Still, however, this panoply is by no means invariably proof against all attacks, as it appears to be well ascertained that leopards and pumas will kill and eat porcupines without the slightest hesitation, and with a total disregard of their formidable spines, which may be found sticking in all parts of the bodies of the devourers. As we found to be the case with the mole-like mammals, all the spiny mammals belong to the lower orders of the class, their several representatives being distributed among the insectivores, rodents, and egg-laying groups, and the majority pertaining to the two former of these. In fact, in this respect an exact parallelism may be drawn between the mole-like and the spiny mammals, each assemblage having several representatives among the insectivores and rodents, while the former has a solitary marsupial type, and the latter two members among the egg-laying mammals. Some of these spiny mammals, such as the true porcupines and the echidnas, are burrowing creatures, and thus have a double means of defence against their enemies; others, however, like the hedgehog, rely on their power of rolling themselves up into a ball, and thus presenting a *chevaux-de-frise* on all sides. Some again, like the tree-porcupines, are more or less completely arboreal in their habits; and the whole of them, like the mole-like mammals, show how urgent has been the need for the lowly-organized rodents, insectivores, and egg-laying mammals to acquire some special means of protection in order to be able to hold their own among the higher forms. As all our readers are doubtless aware, in mammals spines are nothing more than specially modified hairs, and in a porcupine the transition from a spine to an ordinary hair can be easily seen. There are many rodents in which a certain number of scattered spines are mingled with the fur of the back, but our remarks will be confined in the main to the forms in which the spines predominate sufficiently to render them the most striking feature in the external appearance of their possessors.

Commencing with the rodents, our first representatives of the spiny mammals will be the true porcupines (*Hystrix*), which are such well-known creatures as to require but brief description. These animals conform, of course, to the ordinary rodent type in having a single pair of large

FIG. 1.—The Common Porcupine.*

chisel-like incisors in each jaw; and their spines are most developed on the middle line of the head and back, the hinder part of the body, and on the short tail. Whereas, however, those on the body are solid throughout and pointed at each end, the spines at the extremity of the short tail are in the form of hollow quills inserted by

* We are indebted to Messrs. F. Warne and Co. for the loan of the three figures with which this article is illustrated.

narrow stalks. It is these hollow quills that make the loud rattling sound heard when a porcupine is walking; and it appears to us not improbable that they may have given rise to the old legend of the porcupine ejecting its spines when attacked, as such hollow quills might well have been thought to be receptacles for the ordinary spines. Although their owner is unable to voluntarily eject the latter, their pointed bases render them easily detached, and leopards which habitually feed on porcupines are found to be actually bristling with their quills. In attacking its foes, the porcupine rushes at them backwards, and

Fig. 2.—The Common Hedgehog.

thus gives full effect to its weapons. All the members of the typical genus are characterized by their large size, short tails, and highly convex skulls, and are confined to the warmer regions of the Old World. The bush-tailed porcupines (*Atherura*) from West and Central Africa and the Malayan region are, however, of much smaller size, and also distinguished by their much longer tails, which terminate in a brush of flattened spines, and are thus evidently less specialized creatures.

America is tenanted by a group of porcupines easily distinguished from their Old World cousins by having the soles of their feet covered with rough tubercles, instead of being perfectly smooth, and also by their comparatively short spines being mingled with a number of long hairs, by which they may be partially concealed. The Canada porcupine (*Erethizon*) differs from all the other American species in having a short stumpy tail, and also in its non-arboreal habits; its spines being almost hidden by the hairs. In parts of North America these porcupines are so abundant as to be a positive nuisance, and an enterprising engineer, with true American "cuteness," hit upon the original idea of utilizing their bodies as fuel for his engine —apparently with the most satisfactory results. The lighter built tree-porcupines (*Synetheres*), which are mainly characteristic of the southern half of the American continent, are easily distinguished by their long tails, which, as in so many South American mammals, are prehensile. These porcupines are thoroughly arboreal in their habits, and it is therefore easy to understand why their spines are so much shorter than those of their terrestrial Old World cousins, who have to rely solely on these weapons for their protection.

In addition to the members of the porcupine family, there are several other groups of rodents which develop a more or less complete coating of spines. Among the most remarkable of these groups are the spiny mice (*Acomys*) of Syria and Eastern Africa, one of which, when it has its spines erected, is almost indistinguishable at the first glance from a diminutive hedgehog. The spiny rat of Celebes (*Echinothrix*) is another member of the mouse family having the fur thickly intermingled with spines. In a third rodent family (*Octodontidæ*), nearly all the members of which are South American, there is also a genus (*Echinomys*), taking its name from the number of flattened spines mingled with the fur of the back characterizing all its representatives. It will thus be obvious that even in a single mammalian order we have several instances where a protective coat of spines must have been acquired quite independently.

This independent origin is still more clearly indicated when we come to the consideration of the hedgehog and its allies, which bear precisely the same systematic relationship to the porcupines as is presented by the true moles to the mole-voles, as described in our last article. That is to say, whereas the hedgehogs and true moles belong to the insectivorous order, the porcupines and the mole-voles are herbivorous rodents. In spite, then, of the general similarity of appearance between a hedgehog and a porcupine, or, still better, a spiny mouse, we shall find, as already mentioned, that whereas the two latter have the ordinary chisel-like rodent teeth, the former has several narrow and somewhat irregularly-shaped teeth in the front of the jaws, while its back teeth are crowned with numerous sharp cusps, instead of having nearly smooth grinding surfaces. Accordingly, from the purely systematic point of view there is no justification for calling the common hedgehog the "British porcupine"; but, on the other hand, if we allow similarities in external appearance to be our guide in nomenclature, there are just as good grounds for applying the latter title to the hedgehog as there are for giving the names of golden or Cape mole, sand-mole, mole-vole and marsupial mole to four of the creatures noticed in our last month's article. Our ancestors, to whom the hedgehog was commonly known as the "urchin," went, however, a step further than this, and, from the resemblance of its spines to those of the mammal, gave the name of sea-urchin to the *Echinus*, a title which has stuck to it ever since. Systematic zoologists need not then wax so wroth as we have known them do when the name of "British porcupine" is applied to the urchin, seeing that the analogies of nomenclature are sufficient to justify its use. As the sea-urchins come most distinctly under the title of spiny animals, it may be mentioned here that, although the spines of the common British species are not unlike those of the hedgehog, yet their structure is totally different. Thus, whereas the spines of the mammal are of a horny nature, those of the invertebrate owe their solidity to the presence of carbonate of lime, and always break with the characteristic oblique fracture of the mineral calcite. Moreover, whereas the spines of the hedgehog are implanted in its skin, those of the sea-urchin are entirely external, being movably attached by their hollow bases to knobs on the surface of the shell or "test." Whether our worthy ancestors believed that the land and sea-urchins were connected by ties similar to those which in their estimation affiliated barnacle-geese to barnacles, or how the name "urchin" came also to indicate a child, we are quite unaware.

In place of terminating in sharp points, by which they are but loosely attached to the skin, like those of the porcupine, the spines of the hedgehog terminate inferiorly in small knobs, which are placed beneath the skin, and may thus be compared to pins stuck through a piece of soft leather. Beneath the skin lies a layer of muscle known as

the *panniculus carnosus;* and it is by the action of this muscle on their heads that the spines are raised from a recumbent to a vertical position when the creature rolls itself up into a ball—an action of which all porcupines are quite incapable. Not only does the hedgehog differ from the porcupine in this respect, but it is likewise peculiar in using its spines as a means of protection when throwing itself down a vertical bank or precipice, and by this means is able to accomplish a vertical descent of over a dozen feet without the slightest harm. As regards the development of its spiny armour, the hedgehog is perhaps the most highly specialized of all the spiny mammals in spite of the inferior length of its spines as compared with those of the porcupine. Hedgehogs are now represented by about a score of species ranging over Europe, Africa, and a considerable portion of Asia; while the existing genus dates from the middle portion of the miocene division of the tertiary period. That the spines characterizing the existing forms have been independently developed within the limits of the group is pretty conclusively indicated by the close affinity of the hedgehogs to the long-tailed and spineless Malayan insectivores known as gymnuras; fossil types apparently indicating an almost complete transition from the gymnuras to the hedgehogs. In case anyone should suggest that the latter, and not the former, might be the ancestral stock, it may be mentioned that while the gymnuras have a generalized type of dentition and long tails, the hedgehogs have the teeth much reduced in number and specialized in character, and short tails.

In Madagascar the place of the hedgehogs is taken by an entirely different group of insectivores known as the tenrecs, all of which have a certain number of spines mingled with the fur, at least in the young condition, and some of which are so hedgehog-like in general appearance that by the non-zoological observer they would certainly be regarded as members of the *Erinaceidæ*. The tenrecs differ, however, from the hedgehogs precisely in the same manner as the golden moles were shown in our last article to differ from the true moles—that is to say, whereas in the latter the crowns of the upper molar teeth are quadrangular, with their cusps arranged in a somewhat W-like manner, in the former these teeth are triangular, with their cusps arranged in a V. There are five species of tenrecs, classed under three generic headings, and all characterized by the absence or small size of the tail. The largest, and at the same time the most generalized of all, is the common tenrec (*Centetes ecaudatus*), which attains a length of from twelve to sixteen inches, and is characterized by the absence of a tail, by the rows of spines on the back being shed in the adult state, and also by certain peculiar features in the dentition which appear to indicate relationship with the pouched mammals. The spiny tenrecs (*Hemicentetes*) are much smaller animals, of the size of moles, in which the longitudinal rows of spines on the back are retained throughout life. They have the same number of teeth as fully adult individuals of the common tenrec; but whereas in the latter there are four upper molars and two upper incisors, in the spiny tenrecs there are three of each of these teeth. In the loss of the last molar these tenrecs are evidently more specialized than the common species, but the presence of the third incisor shows that they are descended from a still more generalized type. Lastly, we have the hedgehog-tenrecs (*Ericulus*), in which the whole upper surface of the body, as well as the short tail, is thickly beset with spines, thus giving the hedgehog-like appearance from which the creatures derive their name. The dentition is more reduced than in either of the upper groups, thus indicating the greater specialization of the genus; although the presence of a short tail indicates direct descent from a tailed ancestor. Although it is quite clear that the three genera of tenrecs are divergent branches from a common stock, yet it is not impossible that they may indicate the manner in which the complete coat of spines characterizing the third group has been gradually evolved. Against this view it may, however, be urged that if the common tenrec indicated the first commencement of the spiny coat, it would be more likely to find the spines in the adult rather than in the young. Be this as it may, the wide difference between the hedgehogs and the tenrecs, coupled with the affinity of the former to the gymnuras, leaves no doubt that the spines have been acquired independently in the two groups.

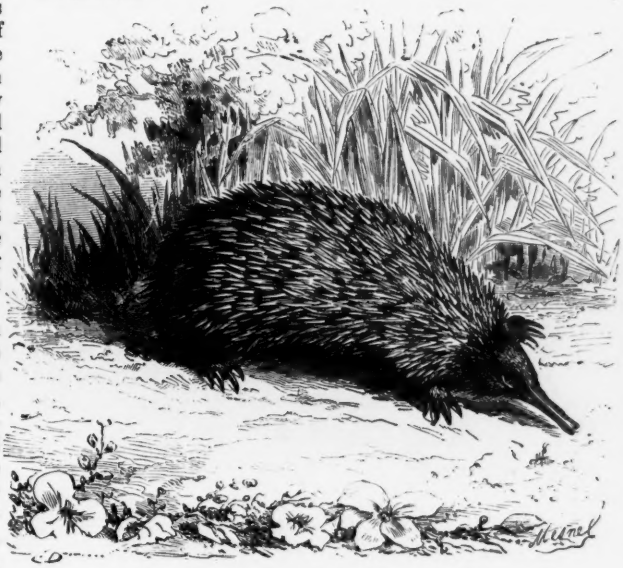

FIG. 3.—The Common Spiny Anteater.

As we found the last representative of the mole-like animals among the pouched mammals, so we observe that spiny animals are represented among the still lower egg-laying mammals by the spiny anteaters, or echidnas, of Australia and New Guinea. As most of the leading peculiarities of the spiny anteaters have been already described in a former article in KNOWLEDGE, treating of the egg-laying mammals, it will be unnecessary to say much on this subject here. The two kinds of echidnas differ, however, externally from all the spiny animals hitherto mentioned in the production of the muzzle into a long, edentulous, tubular beak; and their spines are short, and in some cases largely concealed by the fur. Neither of them have the power of rolling the body into a ball; and, whereas the Australian echidna has five toes to each foot, in the Papuan species the number is generally reduced to three. The wide structural differences separating the egg-laying mammals from all other members of their class render it almost unnecessary to observe that the spines of the echidnas are an entirely independent development. Like so many of the spined mammals, the echidnas have extremely short tails and thick bodies, with the neck indistinctly marked. We have thus decisive evidence that a more or less complete coat of spiny armour has been independently acquired in the following groups of mammals—viz., in the porcupines, mice, and octodonts among the rodents; in the hedgehogs and

tenrecs among the insectivores; and in the echidnas among the egg-layers. From the perishable nature of these appendages we have, unfortunately, no evidence as to the existence of spines among fossil mammals; but, from the foregoing considerations, we are strongly inclined to think they may be mainly characteristic of later epochs.

In this connection it is interesting to notice that the spiny globe-fishes (*Diodon*, &c.), often termed "sea-hedgehogs," in which the spines are bony and therefore capable of preservation, do not date back below the tertiary, and that spiny fishes are unknown in earlier epochs. Moreover, some—although by no means all—of the palæozoic sea-urchins appear to have had very minute spines. Hence, it would rather seem as though the history of spines has been exactly the opposite of that of bony armour, which, as we have shown in our article on "Mail-Clad Animals," has tended gradually to disappear with the advance of time.

Finally, we have to notice the general similarity in appearance of so many of the more specialized spiny mammals, due not only to their bristling coat, but likewise to the general shortness or absence of the tail, and the rounded, plump form of the whole body. The bearing of this independent development of spines in so many groups of mammals, together with the acquirement of a general external resemblance in the creatures thus clothed, on questions of wider import, will (with the editor's permission) form the subject of another article, in which we shall also have to take into consideration the conclusions reached in our previous communication. Before doing this, we may, however, have to lead further up to the subject of "parallelism" by a third article.

CATERPILLARS' DWELLINGS.—III.

By E. A. Butler.

(*Continued from page* 87.)

THE third division of our subject deals with solitary caterpillars which construct portable cases, intended to be their constant, and, in some instances, life-long abode. As the caterpillar walks about, the whole of its body, except the front segments, to which its legs are attached, is enveloped in the case, which is therefore trailed along behind it. While feeding, a similar arrangement is made, but at other times the whole insect is concealed within. Case-making caterpillars are not, as a rule, large insects, and in this country they are almost without exception small species, some of them very minute. The habit is practised chiefly by species belonging to the section Tineæ, the same that contains the little ermine moths already described. Outside of this group there is, amongst British insects, only one other family in which the habit appears, and *they* are a most extraordinary set of creatures. They form the family *Psychidæ*, which is represented in Britain by only a few small insects; in tropical regions the species are more numerous, and many of them much larger.

On the trunks and twigs of trees may sometimes be seen what look like Lilliputian bundles of sticks, each bundle being only about half an inch long, while the stick-like fragments of which it is composed are many of them much shorter than this. On pulling at one of these little piles we find that the fragments are all fastened together into one mass, and that the bundle adheres slightly to its support, but it comes away on the application of a little force. These bundles are the cases of the *Psychidæ* (Fig. 9). Examination shows them to consist of small stick-like fragments of vegetable substance, such as stems of grass and stalks of leaves, which have been collected by the caterpillar, and fastened to the outside of a silken tube. Within, the tube is beautifully smooth, its walls being tapestried with silk. From the opening at the larger end the caterpillar protrudes the front part of its body, enough only to enable it to hold the food and eat. On opening such a case, it would be found to have different contents, according to the time of year. In May the inhabitant would be a caterpillar; later on, a chrysalis; and still later, at about the end of June or in July, nothing more than fragments of an empty chrysalis shell would be found if the insect whose home it was had been a male, but if a female, there would be found a caterpillar-like creature as well. The explanation of this is, that while the male of these insects is a four-winged being like other moths, the female has no wings at all, and looks very much like a caterpillar herself, or sometimes, owing to the absence of legs as well as wings, more like a maggot or short fat worm. The females of this group are in fact the most degraded of all Lepidopterous insects; the males of our British species are rather obscure-looking creatures, of a brownish or blackish colour, whence some of them are known as "chimney-sweeps."

Fig. 9.—Case of *Psychid*, adhering to fragment of leaf; magnified two diameters.

Being utterly helpless and unable to fly, the female never trusts herself outside the walls of her cell, but remaining immured in darkness for the whole of her adult life, receives in that position the attentions of her mate, if she should be lucky enough to meet with one. But such good fortune is by no means the lot of all. The males are far less common than the females; in fact they seem to be almost a superfluous luxury amongst the *Psychidæ*, for the opposite sex find no difficulty in continuing the race without the assistance of partners. In other words, the curious phenomenon of parthenogenesis, or the production of fertile eggs by virgin females, prevails to a surprising extent in this group of moths, so that it is possible to breed them generation after generation and year after year without ever seeing a male. The larva of the male *Psyche*, on the approach of pupation, fastens his case to a leaf or stem by silken threads round its mouth, thus guarding against any mischance during the period of his own helplessness. He then turns round within his case and faces its free end before casting his last larval skin, so that he may be ready, when he becomes a moth, to make his exit at the only available opening, that at the free end, which had previously served for the ejectment of waste matters. Like a Tortrix, therefore, he leaves his chrysalis case projecting partly from his dwelling when he abandons it for ever.

A continental species makes a spirally-coiled case, the silken walls of which are strengthened with particles of sand and other adventitious matter. In shape it somewhat resembles a small snail shell. Certain exotic species from Africa make cases which still more closely imitate the shells of the Mollusca, some being like a flat snail, and others like the pyramidal shells of some of our pond snails (Fig. 10). The larger exotic species are often called "basket-worms," in allusion to the basket-like house in which they are always found, and which, when they are resting, hangs down from the twigs and branches of trees.

Though the cases of the *Psychidæ* in this country are, in consequence of their small size, probably known to none but professed entomologists, the much larger species of the tropics have attracted general attention, and thus have acquired popular names. A certain South African species goes by a complex and unpronounceable native name which, it is said, may be rendered in English, "he that goes with his little house"; and again, in the Colonies, some are known as "walking chips," from the sticks with which the cases are covered. One of these now before me consists of a silken tube, the central portion of which is

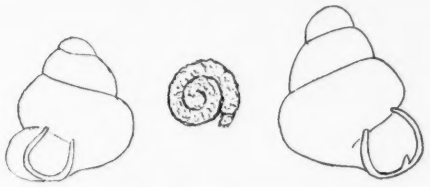

Fig. 10.—Cases of *Psychidæ*, imitating shells; magnified two diameters. (After McLachlan.)

strengthened and made stiff and unyielding by seventeen bits of stick placed longitudinally side by side; all, except one, are of nearly the same length, being about one and a quarter inches long; the single exception is nearly twice this length, and the extra length projects at the hinder end, since it is necessary for convenience of locomotion that all should terminate at about the same level at the mouth end. The ends of the sticks show a rounded bitten surface, where the caterpillar has nibbled them off, and remind one a good deal, though on a small scale, of the similarly rounded ends of the sticks bitten off by beavers. The parts of the tube that project beyond the sticks are covered with small fragments of bark, &c., irregularly placed, and not interfering with the flexibility of the tube; hence, when the caterpillar is on a leaf, the case bends at this part, and hangs downwards in whatever position the insect may be. Amongst nations which believe in the transmigration of souls, there has sprung up the idea that these bundle-bearing insects are the souls of men who, during a former life, have stolen firewood, and are therefore condemned to do penance by being subjected to the drudgery of perpetually carrying about burdens of such a character as to remind them of their former fault!

The cases of the *Psychidæ* forcibly remind us of another set of insects which make habitations almost identical in form. "Caddis worms" are well-known inhabitants of ponds and streams. They are caterpillar-like creatures which may often be seen dragging about their little tubular homes, which are ornamented on the outside with twigs, roots, bits of stick, dead leaves, sand grains, gravel and shells. Some of them, again, make cases which are spirally coiled, and so look like snail shells, thus closely resembling the spiral cases above mentioned. Now if one were to find an empty case of one of these creatures, and were to know nothing of its history, not even whether it belonged to an aquatic or a terrestrial insect, it would scarcely be possible to tell whether it was a caddis case or belonging to one of the *Psychidæ*: and yet the perfect insects are considerably unlike in structure, and are referred to two different orders. The caddis flies, from the absence of the scales on their wings which characterize butterflies and moths, and from peculiarities of the mouth organs, are referred to the Neuroptera, while the butterflies and moths constitute the Lepidoptera; and yet we find that certain species in each order have acquired such closely similar architectural propensities that, although the one set are terrestrial and the other aquatic, and although the protection in the one case is apparently against fishes and in the other against birds, the products of their skill are scarcely to be distinguished from one another. Between the spiral cases of both these groups of insects and the shells of the Mollusca which they mimic, a point of contrast should be noted. The shell of a mollusc is a secretion from its own body, to which it remains attached at a certain point; it is, in fact, a skeleton rather than a house, though an external one. But the spiral case of the insect, on the other hand, is not, except for the silk it contains, a secretion of its fabricator, but is largely built up of foreign matter, and is nowhere attached to the creature's body, so that it is a true house and in no sense a skeleton; it can therefore be changed at pleasure, which of course is not the case with a mollusc's shell.

Turning now to the Tineæ, we find several groups of insects indulging in the habit of fabricating cases. Just about the present season of the year, there may be seen in woods, either resting on the fresh green leaves or fluttering about in the sunshine, a tiny moth with shining dark brown wings which have two little yellowish spots on their inner margins, and with a red head and strongly comb-like antennæ. This is called *Incurvaria muscalella*. It was hatched from the egg nearly a year ago as an insignificant and uninteresting-looking grub, which, as soon as it was out of the eggshell, set to work to mine into the leaf on which it found itself. It spent the first few days of its life as a miner, but soon forsaking this habit, it cut out the roofs of its mine in June, and fastening them together into a flat case, ensconced itself within and descended from the branches to take up a humble position on the ground. Here it lived a haphazard life, eating either dead brown leaves or fresh green ones, as occasion served, and growing very slowly, for it had a long period of larval life before it, and even by the end had not to attain to any great size. It formed fresh cases for itself as its slow growth necessitated. It was full fed in October, but did not choose that time to pass into its next stage. Safely protected in its flat oblong case, it lay about amongst the dead leaves during the winter in a torpid condition. But when spring arrived, it awakened to renewed vigour and became a chrysalis, from which the moth issued as soon as the sun's beams had attained sufficient power to entice it out. Several other allied species have similar habits. The beautiful little moths called "longhorns," with metallic wings and antennæ many times as long as the body, are nearly related to these, and are also case-makers. The perfect insects, some of which are very abundant in woods just now, flutter round the tops of the bushes in the bright sunshine, and at a distance look something like gnats.

But perhaps the most noted of all the case-forming caterpillars are the members of the genus *Coleophora*, which have received that name in consequence of this habit, the word being Greek for a sheath-bearer. They are very small and inconspicuous moths, mostly of exceedingly plain appearance, and as they are of very retiring habits to boot, would certainly never be noticed by the casual observer. We have a great number of species in this country, and the caterpillars' cases are much more frequently seen than the perfect insects, though, being small, they need to be carefully looked for. Amongst the different species there is an endless variety in the shape and appearance of the cases (Fig. 11), but the habits of each species are extremely uniform, so that the nature of the case is generally a good guide to the determination of

XUM

the species that formed it. Some are made of pieces cut from the leaves of the food-plant, and the varied colour, texture, and outline of these are the causes of great diversity in the aspect of the cases. Others are composed wholly of silk, stained usually more or less black; such cases are often shaped something like a pistol, and, when cut open, remind one very much of a pipe-case. Some caterpillars, again, use the husks of the seeds they have been feeding on, and so save themselves the trouble of manufacturing a receptacle. When quite young the larvæ feed as miners in the interior of leaves or seeds; but after a while they change their habits and begin to make a case, either coming out of the mine and spinning a silken pistol-shaped tube, or, like *Incurvaria*, cutting out the two skins of the part of the leaf they have mined, and tacking their edges together with silk. A minute species that feeds on elm ingeniously saves itself the trouble of making two seams by using that part of the leaf which is close to the margin, thus taking advantage of the natural junction which unites the two cuticles there. The outline of the elm leaf, it will be remembered, is notched into a series of tooth-like projections; each of these the caterpillar neatly and carefully excavates, then cutting the cuticles along parallel to the margin, but in one continuous curve, it fastens the severed edges together, making that the lower

FIG. 11.—Cases of *Coleophoræ*; magnified two diameters.

surface of its case, while the upper edge retains the saw-like outline of the leaf. Whatever may be the structure of the case, its inner surface is made beautifully smooth with a lining of silk.

The caterpillar roams about over the leaves on its six front legs, with its body elevated in the air like that of an acrobat, and crowned with the case as with an extinguisher. Its prolegs, ten in number, are very slightly developed, as there is scarcely anything for them to do, and it retains its hold of the case by little hooklets at the end of its body, which it uses like grappling irons. When about to feed, it perforates a little round hole in the cuticle of a leaf, and then begins to mine into the tissues beneath, stretching itself as far forward as it can reach, and thus excavating an irregular blotch. As it grows, its little house in course of time needs reconstruction, as its accommodation is limited and it is easier to construct a new abode than to enlarge the old one. When such a time arrives, the caterpillar mines into a leaf, and having devoured the cellular tissues over a certain area, cuts out the cuticles and fastens them together for the walls of a new domicile, just as on the former occasion. When about to pupate it shrinks into its case, the mouth of which it fastens to a leaf by silken cords; its changes to a chrysalis within, and in the month of July makes its exit at the further end as a fully-developed moth. The cases of the *Coleophoræ* serve not only as a protection to the larvæ during their active summer life, but also, as they all hibernate in the larval condition, render them good service as snug and safe winter quarters.

THE OLDEST BOOK IN THE WORLD.

By J. H. MITCHINER, F.R.A.S.

THE only complete work that, without question, can lay claim to being the oldest book in the world is known as the "Papyrus Prisse," and now forms one of the treasures of the Bibliothèque Nationale. It was presented to the great library of Paris by a Frenchman of the name of Prisse, who discovered the papyrus at Thebes. The tomb in which it was found contained the mummy of one of the Entews of the eleventh, or first Theban, dynasty. The date when the manuscript was written cannot, therefore, have been later than 2500 B.C. But if the exact age of this identical copy should be doubtful, we know precisely, from the text itself, the date of its composition, as it states it was compiled by one Ptah-hotep, who lived in the reign of King Assa. The full title runs: "Precepts of the Prefect Ptah-hotep, under the King of the South and North, Assa." As this king was the last but one of the fifth dynasty, Ptah-hotep, who flourished in the reign of this Pharaoh, and held the distinguished office of "prefect," must have compiled his work about 3350 B.C. Divided into forty-four paragraphs or chapters, the work is something very much more than a mere literary curiosity. It is written in the Egyptian hieratic character; is rhythmic, if not poetic; is addressed to the educated classes, and embodies throughout high and noble principles for the regulation of individual life and conduct, and for the maintenance of good government. The man in authority is enjoined by this very ancient writer to labour at all times to be a true gentleman, lest from his own defects of character he suffer the authority given him by favour of the Supreme Being to be weakened.

An Egyptian Prefect was the highest dignitary in the land, second only in authority to Pharaoh himself. It was the office held by Joseph in the Biblical story: "Only in the throne will I be greater than thou." The Prefect had the custody of the key of the Larit, or royal granaries, to which no entrance could be obtained without the production of the prefectorial seal. The holder of the office was at once the Egyptian First Lord of the Treasury, Chancellor of the Exchequer, and, in his judicial capacity, Lord Chief Justice of Egypt.

All our greatest Egyptologists bear testimony to the extraordinary civilization of ancient Egypt. The work of Ptah-hotep fully confirms this position. It testifies to a height of culture and refinement obtaining in Egyptian society 5240 years ago, that to our Western circumscribed notions of modern superiority are simply inconceivable. The teachings of the "Precepts" more than justify all that has been said by Egyptologists. "It is certain," says Prof. Renouf, "that at least 3000 years before Christ there was in Egypt a powerful and elaborately organized monarchy, enjoying a material civilization, in many respects not inferior to that of Europe in the last century." Leptius writes: "The fourth dynasty ascended the throne about 3124 B.C., and at that time, long before our usual ideas of the development of nations, there is found a people highly instructed in all the arts of peace; a state carefully organized; a hierarchy firmly founded, minutely divided, and organized even to the smallest external matters; an universally diffused system of writing, and the common use of papyrus: in short, a civilization which in all essential points has already attained its full maturity, and only by close investigation is further development in some directions discovered."

M. Mariett says: "Art under the fourth and fifth dynasties obtained a height never afterwards surpassed.

In Egypt the country had also a complicated administration, the result of efforts pursued through long years. There were civil grades as well as religious grades, bishops as well as prefects. Registration of lands was maintained. The king had his court, and a whole world of officials, powerfully and wisely organized, gravitated round him. Literature was held in honour." So also Prof. Maspero: "In one of the tombs of Gizeh, a high officer of the first period of the sixth dynasty (B.C. 3703) takes the title of 'Governor of the House of Books.' Not only was there already a literature, but this literature was sufficiently large to fill libraries, and its importance was so great that one of the court officers was specially designated for the keeping of the royal library." Lastly, Erman of Berlin, also a distinguished Egyptologist, says: "If we have hitherto believed that the immense literature of the dead arose gradually during the long history of the Egyptian people, and that it must be possible to follow the development of their ideas among the Egyptians, we can hold that view no longer. This literature was made at an epoch that lies almost beyond our historical knowledge, and later times did no more than pass it on."

The wisdom and high moral teaching embodied in the precepts of Ptah-hotep abundantly confirm this testimony. This old writer urgently enforces on rulers the cultivation of the doctrine of "Ma," an Egyptian dogma, comprehending "the true, the beautiful, the good." "Ma" is the principle of order and harmony in everything; it is the stedfast pursuit of wisdom, knowledge, and obedience —obedience as the best of all. Although, as in modern expression, we should say "extremely liberal" on many subjects, politically, Ptah-hotep displays an oriental horror of innovators and innovations. Ideas that may be new to the generation are not necessarily new to the world, and changes do not always imply progress. "Good government," he says, "can only be secured by the appointment of good governors. He who is placed in authority over a large number of men must be without reproach, and, in spite of his power, never forget that there are *laws*. The neglect of this principle is the cause of revolutions; when the great forget their duty, why should not the small take their place?" (Chap. 5.) According to Ptah-hotep, contemporary estimates of human actions are not always the most reliable or the most enduring. "Not of the counsel of the flatterers of to-day is it needful to take heed; it is of the judgment of posterity rather, which renders justice to righteous actions." (Chap. 14.) "Only by a consistent life of reverence for knowledge and wisdom; by observing a just moderation in everything; not abusing authority, but by seeking to inspire love rather than fear, can we hope to appear before posterity with honour." (Chap. 6.) The great man is to remember that "he is only the dispenser of the gifts of the Supreme; and if, coming of low origin, he has attained to high honour, he must not, as is too often the case, be puffed up by his good fortune, but should consider the new duties which his rank imposes on him as the steward of the Almighty." (Chap. 30.)

In sixteen different instances in which Ptah-hotep speaks of God, he does so in the singular number—an argument happily no longer needed to establish the monotheistic character of the Egyptian religion. He ends by saying: "I have reached one hundred and ten years of life, blessed by the favour of the king, among the first of those who have exalted themselves by their works, doing the pleasure of the king in an honoured position."

The work terminates with the colophon: "It is finished, from its beginning to its end, according to that which is found in writing."

"The Precepts of Ptah-hotep" have been translated from the hieratic into French by M. Virey, and re-translated into English by Prof. Osgood. They reveal throughout the mind of one who all his life has been accustomed to the higher walks of society in a well-ordered state. The sixteen pages of the "Precepts" are, in the manuscript, preceded by a few leaves of a still earlier work, written by one Kakimna, Prefect to King Seneferu, of the third dynasty. Had this work been complete, we should have been able to boast of a book older than the Pyramids, and dating from 3760 years before Christ—a book 5650 years old!

By the courtesy of the Principal Librarian at the Bibliothèque Nationale, the writer, since the above was written, has had the opportunity of inspecting the document. It is in the hieratic character, in two colours, red and black, and in a truly wonderful state of preservation. Nothing could well improve the arrangements for its safe keeping, every sheet of the papyri being carefully covered with glass, and secured from light and dust.

Science Notes.

The last number of *Astronomy and Astrophysics* contains a remarkable photo-lithograph showing the disc of the sun covered with a network of faculæ. The picture is a photograph of a drawing made from negatives taken by Prof. G. E. Hale on April 16th, 1893, the day of the recent eclipse. The solar photographs were projected on a screen of white paper with an optical lantern, and tracings were made from them showing faint details which Prof. Hale believes would have been lost in direct photographic reproductions. The solar faculæ, instead of being shown as great white masses, are broken up into curving linear forms, which interlock with one another, giving the appearance of a kind of network extending over the whole of the sun's disc, though it is brightest in the southern hemisphere, and especially in the region of spot development.

The exploration of the higher atmosphere by means of balloons has led to some interesting results in France. A balloon, carrying registering meteorological instruments, was sent up by M. Gustave Hermite on March 21. Its volume was nearly 150 cubic yards, and the whole weight of the apparatus, including an automatic distributor of inquiry cards, was about thirty-seven pounds. The lowest pressure registered was 103 millimetres (four inches), that is, rather less than one-seventh of an atmosphere, which corresponds to a height of about ten miles. At a height of nearly seven-and-a-half miles the temperature recorded was —51° C., or —58·2° Fahr. The freezing of the ink of the recording instruments then caused a break in the curves of temperature and pressure. Subsequently, however, the ink was thawed (probably by the intense solar radiation), and a temperature of —5° Fahr. was indicated at ten miles. In the famous balloon ascent by Messrs. Glaisher and Coxwell in 1862, the temperature observed at a height of seven miles was —12° Fahr.

There is in use at Millwall Docks a novel and ingenious machine for discharging cargoes of grain in bulk, the principle applied being the removal of the grain by the creation of a strong current of air. The machine is erected on a barge, which is placed alongside the ship to be unloaded. One end of each of six 5-inch flexible pipes is attached to the machine, the other ends being carried into the hold or holds of the vessel and immersed a few inches in the grain. When the engine is started the grain immediately flows at the rate of one hundred tons an hour

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through the pipes into receivers, whence it falls by gravity into weighing machines, and then, again by gravity, into the craft sent out by the purchasers to carry it away.

Natural Science announces that the work of remounting the great series of microscopic preparations made by the late Prof. de Bary, and acquired by the British Museum, is nearly completed. To students of botany the presence of this large collection in the country will be a great benefit.

In the last issue of the "Proceedings of the Zoological Society," Mr. R. Lydekker describes an interesting series of Cetacean remains from the eocene of the Caucasus. Among these, special importance attaches to certain bones belonging to the imperfectly-known creature designated *Zeuglodon*, which Prof. D'Arcy Thompson has recently endeavoured to remove from its assigned position among the whales to associate it with the seals. The most important specimen among the new find is a humerus bone of which but one example has been hitherto known, and the study of this leads the author to conclude that *Zeuglodon* is much more likely to be an ancestral Cetacean than a seal.

An important find of water is reported within "the London Basin" of geologists, in Windsor Forest. After boring for 1234 feet, water was found, and rose seven feet above the surface, though the site is on a hill 223 feet above sea level. This welcome supply comes from the lower greensand. As a Commission is now at work on the London Water Supply question, this discovery may have important results.

The Board of Agriculture has issued a valuable report on rust or mildew on wheat plants. It contains a complete account of the life-history of the fungus of ordinary mildew, *Puccina graminis*, as well as that of spring-rust and mildew, *Puccina rubigo vera*, with a discussion of the conditions favourable for their propagation, and the best means of averting them. It is illustrated by some excellent coloured plates by Mr. Worthington Smith.

Dr. J. Rahon has recently contributed to the Anthropological Society of Paris an interesting paper entitled *Recherches sur les Ossements Humains Ancien et Préhistoriques.* This paper is the fruit of most laborious investigation. The author concludes that the bones both of men and women were rather heavier and more powerful in ancient times; also that the tribes of neolithic times in Western Europe were of a medium height, of about 1·63 metres.

The Rev. F. J. Smith, Millard lecturer in mechanics at Trinity College, Oxford, has devised a means by which pictures of old coins, and similar objects, can be made electrically. The coin, medal, or engraved plate of which a figure is required, is made to form one of the metallic coatings of an electrical condenser; a photographic plate, or a piece of bromide paper, being placed between the two. When a condenser so arranged is subjected to rapid charge and discharge, by connecting the coatings with the terminals of an induction coil, or a similar source of electricity, for a fraction of a second, the prepared surface of the dry plate is chemically altered, and upon developing the plate in the usual manner a picture of the coin or medal will be found upon it. Pictures can be produced in this manner even when the sensitized plates have been exposed to full daylight. The best results are obtained by conducting the process in oxygen gas under a pressure of about two atmospheres.

It has been resolved by the Council of the Zoological Society to award the Society's Silver Medal to Donald Cameron, of Lochiel, and John Peter Grant, of Rothiemurchus (Inverness-shire), in recognition of the efforts they have made to protect the osprey (*Pandion haliatus*) in Scotland. The osprey, formerly common in many parts of the British Isles, has become so rare of late years that it is stated that only three pairs of this bird have been known to breed in this country for some years past.

Those who desire to keep in touch with the progress of science outside their own departments will welcome the appearance of the second volume of the "Year Book of Science" (Cassell & Co.), edited by Prof. T. G. Bonney, F.R.S. It has been extended so as to include geography and anthropology, and more space is devoted to anthropology. The list of contributors contains many well-known names. There is an index of subjects as well as one of authors.

M. Rykatchef has made an investigation of the variations in the temperature of the air over the oceans in the tropics, which is described in the *Transactions* of the St. Petersburg Academy of Sciences for October 19th. He finds that the minimum daily temperature is reached about one and a half hours before sunrise, and the maximum almost immediately after mid-day. The variation of the mean temperature throughout the whole twenty-four hours is very small, being only 2·9° Fahrenheit.

M. Angot exhibited several beautiful photographs of cirrous clouds at the French Physical Society on February 3rd. In order to stop out the blue colour of the sky, coloured screens were employed, the best results being obtained by using a solution of copper sulphate (ten parts) and potassium bichromate (one part), to which a few drops of sulphuric acid is added. With such a solution in front of the lens of a camera, and orthochromatic plates, excellent cloud photographs are obtainable.

The mammoth gum trees of Australia are the largest trees in the world, not excepting even the sequoias of California. The loftiest tree on the globe, according to Baron von Müller, is the *Eucalyptus regnans.* One of these trees in the Cape Otway ranges measured, when felled, 415 feet in length. Gum trees grow very rapidly. The *Eucalyptus globulas* grew 40 feet high in four years in Florida, with a stem a foot in diameter. Trees of the same species in Guatemala grew 120 feet in twelve years, and had a stem diameter of nine feet.

A few facts significant of progress in India are noted by Dr. H. R. Mill in a recent number of *Nature.* He says that the newly-published report of the Bengal census shows that there is a steady transference of population from the most densely to the more thinly-peopled parts of the province. Would that the same remark could be made as to the population of England! Mohammedanism is increasing rapidly in Bengal, and the custom of widow marriage among Hindoos has become common.

From measurements of an arc along the parallel of 47½° in Russia, M. Venukoff has found a length of 1,446,462 metres for a difference of longitude of 19° 11′ 55·11″, or 75,336 metres (46½ miles) per degree. The rate of diminution in the lengths of degrees of longitude deduced from the Russian results does not agree with that given by French and English measures; it indicates a polar compression of $\frac{1}{299\cdot65}$, whereas the value given by Clarke is $\frac{1}{293\cdot46}$.

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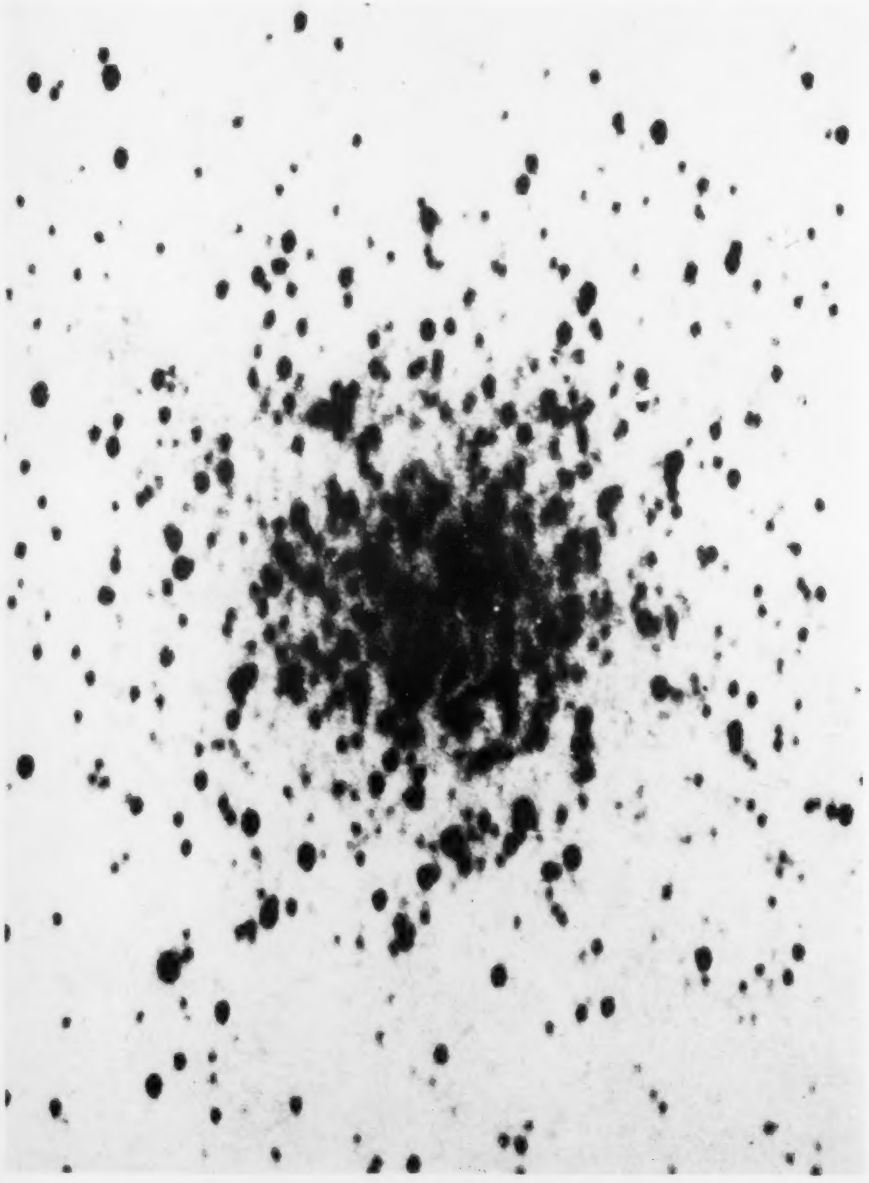
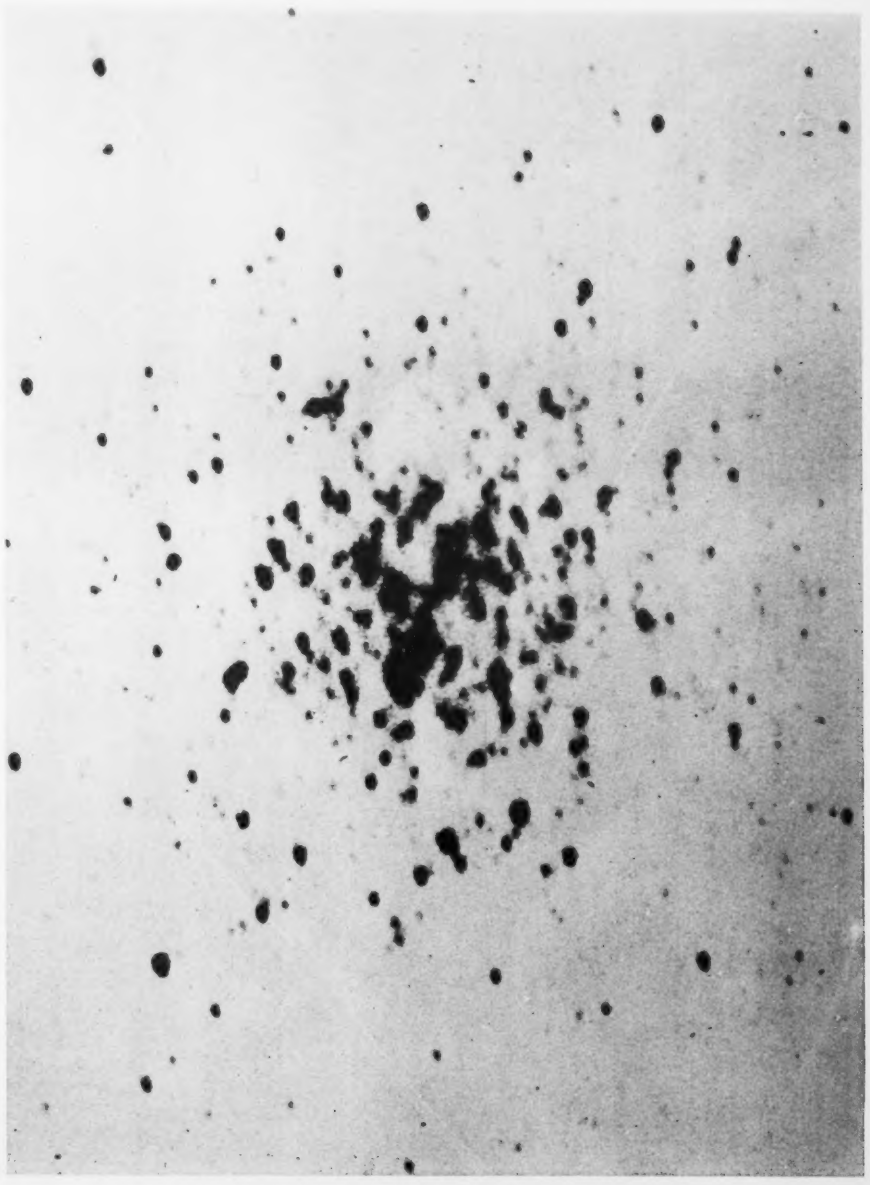
Focal Length of Lick 36-inch Refractor, 570 inches. Scale of these enlargements, about 80 inches to the degree.



THE CLUSTER IN HERCULES (Messier 13).

Enlarged about eight times from a Photograph taken with the 36-inch Refractor of the Lick Observatory, on 24th May, 1892. Exposure 156 minutes.



THE CLUSTER IN HERCULES (Messier 13).

Enlarged about eight times from a Photograph taken with the 36-inch Refractor of the Lick Observatory, on 28th July, 1891. Exposure 122 minutes.

Observatory, on 24th May, 1892. Exposure 150 minutes.

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WHAT IS A STAR CLUSTER?

By A. C. RANYARD.

FORTY years ago, when it was generally believed that star clusters were stellar universes similar to the Galaxy which spans the heavens, it was assumed that the individual stars of clusters would bear comparison—as to magnitude and brightness—with our sun. It was then pretty generally believed that the stars of clusters were only rendered dim by distance, and that they were separated from one another by interspaces similar to the star depths which separate us from the isolated stars dotted over the heavens, many of which are evidently associated with the Milky Way; but as time went on, it was seen that the clusters and nebulæ were in many instances evidently associated with the Milky Way, and that the clusters which are grouped about the Milky Way are probably at about the same distance from us as the Milky Way, and as the numerous bright stars which are evidently associated with it. Such considerations made it evident that the individual stars of the clusters associated with the Milky Way must be very small or very dim compared with the brighter Milky Way stars.

Determinations of parallax and the results derived from the observed motions and brightness of double stars seem to point to the conclusion that many of the fixed stars are actually smaller than our sun, and that, as a rule, the stars do not very greatly exceed the sun in mass or brightness. We are, therefore, forced to conclude either that (1) the Milky Way stars must be immensely large or intensely bright compared with our sun and the other stars whose mass and brightness we have been able to approximately estimate, or (2) that the individual stars of clusters associated with the Milky Way must be very small or very dim compared with our sun.

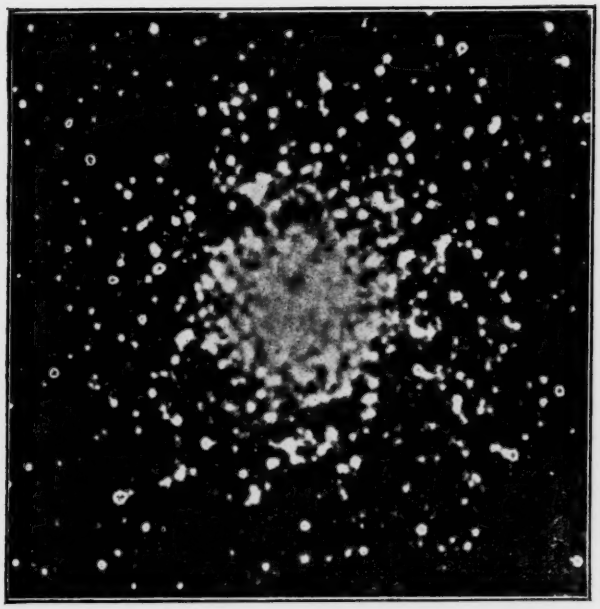

FIG. 1.—Untouched etched Block made from a Photograph of the Cluster in Hercules, taken by the Brothers Henry on the 23rd June, 1886.

The cluster in Hercules shown in our plate is just visible to the naked eye, and its total light is probably about equivalent to the light given by a sixth magnitude star. It may be shown that (if there were no absorption of light in space) our sun would appear to shine as a star of about the sixth magnitude if it were removed to a distance

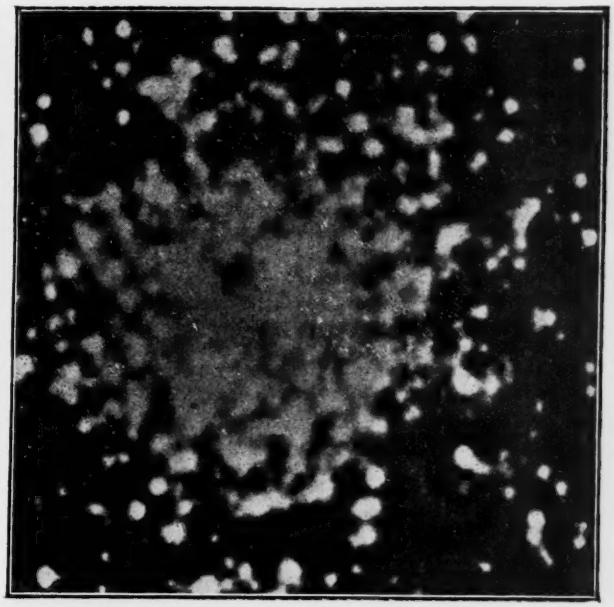

FIG. 2.—Untouched etched Block from the Henry Photograph of 23rd June, 1886, on the same scale as the Enlargements made from the Lick Photographs, shown in the Collotype Plate.

corresponding to a parallax of a tenth of a second, that is, if it were removed to a distance about seven and a half times as great as the distance of our nearest stellar neighbour, α Centauri. At such a distance our sun would give us about as much light as we derive from the whole of the stars of the Hercules cluster, and at such a distance a sphere equal in diameter to the orbit of Neptune would subtend a diameter of about six seconds, as seen from the earth; but the denser part of the Hercules cluster has a diameter of about three minutes. Consequently, if a quarter* of the photosphere of our sun were torn into small fragments and scattered in space within a sphere of thirty times the diameter of the orbit of Neptune, or nine hundred times the diameter of the earth's orbit, we should (supposing the fragments of photosphere to retain their brightness and to be all placed square to the line of sight) have a cluster of small stars which, as seen from a distance seven and a half times as great as the distance of α Centauri, would present an appearance similar in brightness and diameter to the Hercules cluster. If the Hercules cluster is at double the above distance, the diameter of the cluster and of the individual stars would need to be doubled, and their volume and mass would need to be multiplied by eight. But the assumption that this cluster and the other clusters scattered along the Milky Way are at fifteen times the distance of α Centauri, forces us to assume that the brighter stars associated with the Milky Way are on a gigantic scale compared with α Centauri and the other stars whose mass and brightness we have been able to estimate. If the Hercules cluster is at only four or five times the distance of α Centauri, the individual stars of which the cluster is composed must be

* The solar disc from which we receive light only corresponds in area to half the hemisphere turned towards us, and to a quarter of the whole solar surface.

very small indeed, or very dim compared with our sun; and assuming them to have a brightness equal to the brightness of the sun's photosphere, they would not much exceed our earth in size.

When we look at the arrangement of the stars in this cluster, we find that we have evidence of the association of many of the stars into groups linked together by faint nebulous bands. Long ago Sir John Herschel noticed the curvilinear streams of stars radiating from the central regions of clusters, and, as mentioned in the last number, he remarked on the difficulties of conceiving of the permanent conservation of such a system as a globular cluster, if the individual stars are conceived of as moving round a common centre of gravity. Miss Clerke, in her "System of the Stars," remarks on the "radial alignment of the components of clusters inevitably suggesting the advance of change, whether in the direction of concentration or diffusion; either the tide of movement is setting inward, and the 'clustering power' (to use a favourite phrase of Sir William Herschel's) is still exerting itself to select stars from surrounding space, or else a centrifugal impulse predominates."*

It seems to me that stars falling towards the cluster from surrounding space would probably not be arranged in rows, and that the forms of several of the radiating groups of stars which are seen to be linked together by bands of nebulosity indicate that the group is moving from the central parts of the cluster outwards, through a resisting medium which is dense enough to contort the outward moving mass. Possibly the stars may fall back singly, or the stars and nebulous matter may fall back again to the cluster in a cooled and non-luminous form, but I do not trace any evidence of prominence forms with their heads turned towards the centre of the cluster, or any linear groups of stars forking towards the centre of the cluster. Though there are many such linear groups of stars which branch or fork outwards, the physical interpretation of these prominence-like and branching structures seems to me so important that I have made an effort to exhibit them to the readers of KNOWLEDGE. I am indebted to Mr. McClean, of Tunbridge Wells, for the excellent enlargements of the photographs of this cluster made at the Lick Observatory, which are shown in the collotype plate, as well as for the loan of a contact copy from one of the Lick negatives, a close study of which I have found very instructive. The blocks have been made from enlargements of a photograph of the cluster taken by the Brothers Henry at the Paris Observatory, and they are quite untouched, though the process has been arranged so as to give prominence to the faint ligatures of nebulosity joining the lines of stars.

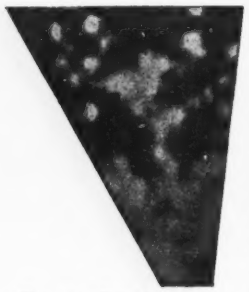

FIG. 3.—Prominence-like Structure.

The prominence-like structure shown in Fig. 3 should be compared with the collotype plate from the Lick photographs, as well as with the cluster as shown in Fig. 1. It seems to be a broad-headed structure, with a contorted, spirally-twisted stem joining it with the central mass of the cluster. In the right-hand picture on the plate made from the Lick photograph of July 28th, 1891, the narrow stem beaded with stars can be traced, while in the denser picture of May 24th, 1892, the bright head of the prominence seems to be almost severed from the curving lower part of the stem; but an examination of all the photographs convinces me that the spreading head is joined on to the lower part of the stem by a ligature of nebulosity which probably takes a bold spiral sweep, and joins up with the lower part of the stem at the cusp marked by the bright star. On the denser Lick photograph of May 24th, 1892, at least two faint strings of minute stars joined by a ligature of nebulosity may be traced branching away from the bright prominence-like structure, or possibly seen in projection in its immediate neighbourhood.

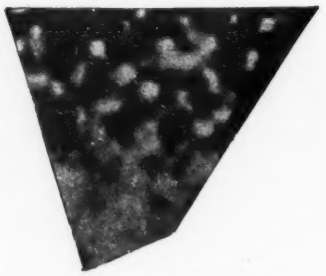

FIG. 4.—Strings of Stars linked together by Nebulosity.

The structures shown in Fig. 4 are from the upper part of the cluster to the right of the prominence structure referred to. The structures will be best seen by a reference to the collotype plate from the denser Lick photograph, but the strings of stars, and the nebulosity linking them together, can also be recognized on Fig. 1, made from the Henry photograph. The streams of stars are not straight, and seem to afford evidence of having been contorted by a resisting medium.

Fig. 5 shows a very curious structure, which has the appearance of being a spiral stream of nebulous matter and stars, with a spreading or forked summit. This structure is immediately below that shown in Fig. 4, and extends radially from the right-hand side of the cluster. It is well worthy of close study, and should be compared with the Lick plates and with Fig. 1. If we admit that this is a vast spiral structure, it seems to follow that the resisting medium through which the ejected matter was projected upwards is sufficiently dense, compared with the ejected matter, to permit of vast storms causing cyclonic action. We occasionally find prominence forms upon the sun, showing distinct evidence of cyclonic action. A notable instance of such a twisted solar prominence was photographed by Colonel Tennant during the total eclipse of 1868, and is well shown in the plates made from his photographs published in the "Memoirs of the Royal Astronomical Society," Vol. XXXVII., Plates 5c and 5d, and on a larger scale in Plates 6, 7, and 8 in the same volume. We know that at the level of the solar prominences the pressure of the solar atmosphere, or resisting medium through which the prominences are projected, is so small that the lines of the prominences, as shown in the spectroscope, are quite narrow, and it seems probable that the cyclonic twist must be given to such prominence matter at a much lower level than the level of the photosphere. Similarly, it seems possible that the spiral twist shown by the structures in Figs. 3 and 5 may have been given within a gaseous envelope in the central region of the cluster. The flattened and spreading heads of prominences may be due to the rapid motion of the prominence matter through a very thin resisting medium, or even

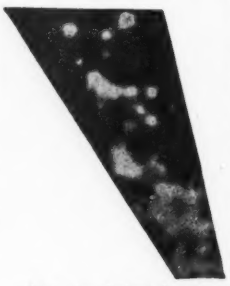

FIG. 5.—Spiral Stream of Nebulous Matter and Stars.

* "The System of the Stars," p. 244.

to their motion through a fine rain of falling matter, but we can hardly conceive of a spiral form being given to an outrushing filament unless it was projected from the centre of a cyclonic storm, or was deflected in its passage through a resisting medium by lateral currents. The fact that the stellar points follow the lines of the nebulous curves, seems to indicate that the stellar aggregations have formed within the nebulous filaments after their deflection; for if the stellar aggregations differ appreciably in density from the nebulosity joining them, the resisting medium would have a less effect in diminishing the momentum of the denser portions, and the denser masses would drift on in front of the less dense portions and get separated from the general line of nebulosity.

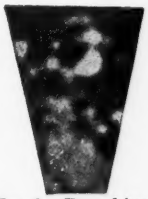

FIG. 6.—Branching Structure.

Fig. 6 represents a branching structure adjacent to the spiral form shown in Fig. 5. The narrow bands of nebulosity linking the stellar regions is well shown in it, as also in the branching structure shown in Fig. 7.

FIG. 7.—Forked Structure.

In addition to the bright structures shown in these illustrations, there seems to be evidence of the existence of dark branching forms associated with the cluster. The Earl of Rosse at Parsonstown in 1850, noticed three "dark lanes" meeting at a point considerably removed from the centre of the Hercules cluster, and the Rev. T. W. Webb describes these dark lanes in his "Celestial Objects" as visible with a nine-inch reflector. They form quite a striking feature of the cluster as seen with larger apertures, and are distinctly traceable on a dense photograph of the cluster taken by Mr. Isaac Roberts in May, 1887—a photograph of which has been well reproduced in Miss Clerke's "System of the Stars," plate 9. But the photographs now reproduced do not extend quite far enough to show the triple dark lanes discovered by the Earl of Rosse, though they can be distinctly made out upon the original copies from which the illustrations for this paper have been prepared. In these,and in the glass dia-positive of the Lick photograph lent me by Mr. McClean, there appear to be several other small dark branching structures which can be distinctly made out in different parts of the cluster. They are clearly not merely lacunæ between bright structures. They interfere with the nebulous background and with the bright regions in a way that can only be accounted for by supposing that a branching stream of light-absorbing matter is situated between the eye and the cluster, probably in the immediate neighbourhood of the cluster; a few such branching channels may be traced in the central parts of Fig. 1, though they are not very conspicuous. It, however, seems probable that the cluster is a group of nebulous structures, some bright and some light-absorbing; the bright structures being studded with brighter regions, which appear as stellar points in the telescope.

If the cluster is situated at a distance seven and a half times as great as α Centauri, the bright regions might have a diameter 500 times as great as that of our sun, and yet hardly be distinguishable, except in the largest instruments, from stars. For our sun, if it were removed to a distance seven and a half times as great as α Centauri, would only appear to have a diameter of 0·00096″ as seen from the earth. Consequently, nebulous clouds with a diameter twice as great as the diameter of the earth's orbit would, at such a distance, appear to have a diamete of less than half a second of arc, and would be hardly distinguishable, except in the largest instruments, from stellar points. We are, therefore, hardly in a position to say that the stellar points are sun-like bodies with a brilliant photosphere, and are not merely brighter regions in the nebulous streams or structures radiating from the cluster.

Mr. Burnham, in commenting on a close pair of star-like points near to the centre of this cluster, which he examined with the 36-inch Lick refractor, and found to be separated by a distance of only 0·88″, says:* "This is one of the principal stars, near the central portion of the great cluster in Hercules. It was the only pair close enough to be called a double star I could find on this occasion, but the conditions were not specially favourable. Of course, there are many stars within, say, 2″ of each other, but in all of the bright compressed clusters which I have examined with this and other instruments there seems to be a remarkable absence of real double stars; and this seems to be true of star clusters generally."

Mr. Burnham notes four or five comparatively close pairs in the Pleiades and in the cluster in Perseus, but they may (as well as the pair in the Hercules cluster above referred to) not belong to the clusters but only be seen by projection upon them. If we accept Prof. See's theory as to the evolution of double stars from nebular masses whose velocity of rotation has been accelerated by the shrinkage of the mass due to cooling, the existence of a binary star in a cluster must be taken as indicating that the secular changes which give rise to binaries have not had time, since the isolation of the stars as separate masses, to produce their effects; and the absence of binaries may be taken as indicating the comparatively recent separation of the stellar masses.

Notices of Books.

Observational Astronomy: a Book for Beginners. By Arthur Mee, F.R.A.S. (Cardiff: Daniel Owen & Co., 1893.)—This is an excellent, honest little book, containing a good deal of out-of-the-way information about things astronomical, especially amateur astronomers and their instruments. It is profusely illustrated, though the diagrams are sometimes rather rough. The series of drawings of lunar craters by Mr. Mee, Mr. Stanley Williams, Mr. Gwyn Elger, and Mr. G. T. Davis are worthy of special attention. One of the quaintest illustrations in the book is a picture of the Orion nebula as seen by Mr. Mee with an 8½ inch reflector. It is as unlike the photographs of the nebula as any of the drawings by early astronomers collected in Prof. Holden's memoir, from which he and some other astronomers have argued that striking changes are taking place in the comparatively short period during which man has been observing the nebula. One of the most interesting parts of the book is the memoir of the Rev. T. W. Webb, Prebendary of Hereford and author of "Celestial Objects for common Telescopes." It contains a few too short extracts from some of his letters, of which there must be a great number treasured up in different parts of the world, for he was a most voluminous and interesting letter writer, always ready to assist the amateur astronomer. His letters were written in a neat small-hand which enabled him to put a great deal into the page, and they were frequently illustrated with charming little drawings as well as enlivened by the quaintest humour, which, of its kind, was as curious as De Morgan's. The woodcut from a photograph of Mr. Webb is unfortunately not a success, and

* "Astronomische Nachrichten," Bd. 127, p. 382. The place of the double star referred to is, R.A. 16h. 37m. Dec. + 36° 41′.

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will hardly enable his friends to recognize him; but Mr. Mee gives a good portrait of Prof. Adams, of Prof. Barnard, and of the too little known and not sufficiently appreciated John Dollond, inventor of the achromatic object glass.

The Nests and Eggs of British Birds. By Charles Dixon. (Chapman and Hall).—Mr. Charles Dixon handles his subject in a scientific manner, and the book will no doubt do much to develop an intelligent study of the habits of birds. It is written in such simple and attractive language that it will easily be understood by schoolboys. Mr. Dixon's plan has been to give the British breeding area for every species treated of, with its breeding habits, description of eggs and nest, and characteristic marks for easily distinguishing one species from another. Mr. Dixon could probably have made the book still more interesting, without detracting from its scientific value, if he had added some more of his own observations in egg-collecting. He informs us in the preface that he has taken the eggs of almost every British species, and his experiences must therefore be both varied and interesting. The volume will prove a very valuable addition to ornithological literature.

Kayser's Text Book of Comparative Geology.—Text Book of Comparative Geology, by E. Kayser. Translated and edited by P. Lake. London, 1893; 8vo, pages xii. and 426, illustrated. (Swan, Sonnenschein & Co.)

Superlatively excellent as is the geological series displayed in the British Islands, from constantly studying text books which take that series as their type, English students have a tendency to become somewhat "parochial" in their geology, and we therefore gladly welcome an elementary work on that science written from a German standpoint, and now made fully available to the British geologist. In saying that the book is written from a German point of view it must not, however, be inferred that the geology of Germany has an undue pre-eminence assigned to it; the fact being that the different formations are described most fully from the regions where they are best developed. For instance, we have the chief description of the silurian taken from Britain, the devonian from the Rhenish district, the carboniferous from Britain, and the jurassic from Central Europe.

After an introduction on the general principles of geology, the various geological systems—commencing with the lowest—are in turn treated historically, stratigraphically, and palæontologically, the method of treatment being as broad and full as appears possible in a work of this size. Almost for the first time in an English text book we have the latest views as to the nature of the archæans set fully before the student, to whom it is pretty clearly suggested that the complex origin of these rocks finds most favour with the author.

The illustrations of fossils in the book are both numerous and well selected, and, although not very artistic, display the characteristic features of the types depicted most clearly. In addition, there are numerous excellent stratigraphical sections, mostly from the Continent. The geologist pure and simple will perhaps not be over well pleased to find the various groups of ammonites described and figured under the numerous generic titles which have of late years been coming more and more into use; but this is a change to which we must apparently all make up our minds.

The weakest portions of the book are those relating to vertebrate palæontology, in which the author or his translator would have done well had they sought special advice. For instance, on page 279, we find it stated that all jurassic mammals belong to the so-called pantotheria, which are affiliated (page 284) to the monotremes; while the Stonesfield slate is mentioned as the only English horizon from which they have been obtained. Again, the distinction between ichthyosaurs and plesiosaurs (page 275) is decidedly badly indicated; while on page 324 we are surprised to learn that all the birds with teeth have biconcave vertebræ. Further on (page 351) we are told that the creodont *Proviverra* is a marsupial; while on the next page the same genus is, if we mistake not, alluded to among the carnivores as *Protoviverra*, and *Hyænodon* is said to be allied to the hyænas! It is also news to us that *Cebochœrus* is a monkey (page 353); while even the proverbial schoolboy probably knows that it is quite inadmissible to speak of the moas as the ancestors of the kiwis (page 398).

In spite of the above faults in one particular section, we can conscientiously recommend the work to geological students as a well-written, compact, and, at the same time, comprehensive text book, in which the science is treated on broad and philosophical views from the historical, stratigraphical, and palæontological aspects.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

SIRIAN AND SOLAR STARS.

To the Editor of KNOWLEDGE.

SIR,—I ask space for some remarks in reply to your criticisms on my letter, and also on Miss Clerke's article in your April issue.

Sirian stars, are no doubt, photographically brighter than solar stars of the same photometric magnitude, but I do not think that this can be the explanation of Prof. Kapteyn's results as to the photographic brightness of galactic stars. If the Sirian stars are more numerous in the Galaxy than in other parts of the sky (which I think has hardly been proved), this is at all events only true as an average result. So far as I have compared the catalogues, the richest region of Sirian stars (including type B of the *Draper Catalogue*) rather runs across than stretches along the Galaxy. It runs from Canis Major to Auriga. Starting from a point on the Galaxy in Monoceros, you will meet a richer Sirian region by moving nearly at right angles to the Milky Way than by going along it; but Prof. Kapteyn thinks that there is a continuous diminution of photographic brightness as we move outwards from the Galaxy. I can find no such continuous diminution of the proportion of Sirian stars as we pass outwards. Mr. Marth, I think, gives all the stars within the limits examined by him which were measured at less than 6·0 in the *Harvard Photometry*. On the other hand, Prof. Pickering's Milky Way region extends considerably beyond the limits of the Milky Way, and includes, I think, the whole of the rich Orion-Taurus region to which I have already referred. But the Milky Way elsewhere presents different features. In Sobieski's Shield, for instance, the solar stars seem to preponderate.

Of the brighter stars, no doubt many owe their high magnitude to their great mass or intense illumination. We may expect to meet with a good many of these in the Milky Way, but they are not confined to it. Betelgeuse and Rigel appear to be as remote as any bright star in the Galaxy. Altair, 61 Cygni, and η and μ Cassiopeiæ, on the other hand, seem to be certainly nearer to us than the Galaxy, unless the true shape of the Galaxy is a disc (the sun being placed in a comparative vacuity) rather than a ring. If the Galaxy is a ring, I think it will be found that all the solar stars which are brighter than the sixth

magnitude lie between us and the ring, and that a considerable number of the brighter Sirian stars do so. As far as the solar stars are concerned, this conclusion falls in with Prof. Pickering's.

I do not think Prof. Kapteyn assumes that proper motion is to be regarded as a measure of the distance of a star. He considers it established (and I made a similar remark) by the fact that stars with large proper motion afford as striking evidence of the motion of the solar system in space as stars with small proper motion; to which it may be added, that spectroscopic observations do not show that stars with large proper motion have a greater average velocity in the line of sight. Undoubtedly, however, further observation is necessary before we can say positively that the solar stars are or are not (on the average) moving with greater absolute velocity than the Sirian. Sirian stars with considerable proper motion are not numerous, while the measurement of small proper motions involves great uncertainty. But to the objection that a fast-moving group of solar stars could not exist as a system there are many answers. First, Prof. Kapteyn seems to be of opinion that their motion is only apparently and not really faster than elsewhere. Secondly, he thinks it at least possible that the proportion of solar stars is equally great at greater distances, the faintness of remote solar stars being the only reason why this fact has not been recognized. (I have, I think, also suggested both of these points.) Thirdly, it does not follow that what may now be regarded as a cluster forms a permanent and stable system; and lastly, the apparently rapid motion of this cluster may arise (at least in part) from the sun being a runaway star, as 1830 Groombridge is supposed to be.

Prof. Kapteyn does not seem to have drawn the distinction between Capellan and Arcturian stars, which I think will prove to be of almost equal importance with that between Sirian and solar. The cluster round the sun (if it be really a cluster and not merely an average specimen of what is to be met with throughout space) seems to be pre-eminently a cluster of Capellan stars.

Truly yours,
W. H. S. MONCK.

[I was mistaken in saying that Mr. Marth's Catalogue of Milky Way Stars did not include all stars down to the sixth magnitude. His original catalogue did not, but his recent catalogue includes all stars in the neighbourhood of the Milky Way down to the sixth magnitude of the Harvard Photometric Catalogue.

Many of the stars with swift proper motions are moving athwart the direction of the sun's motion in space, and the apparent motions of some of them are more or less parallel to and in the same direction as the sun's motion. These motions cannot be accounted for as only apparent and due to the sun's motion. We may, therefore, assert with some certainty that such swift-moving stars cannot be, as it were, anchored in space, controlled by the gravity of a cluster of a few hundred stars similar in mass to our sun.—A. C. RANYARD.]

THE η ARGÛS REGION OF THE MILKY WAY.

To the Editor of KNOWLEDGE.

SIR,—Few regions in the heavens can equal this in interest when we consider the remarkable changes in the variability of the principal star and the appearances of the star-cluster and nebula surrounding it; to use Miss Clerke's expression, "the crowd of small stars embroidering one of the finest of the southern nebulæ." Photography now enables some of those who have not had the advantage of seeing this glorious object directly to examine it in the plates which Dr. Gill has brought over from the Cape; and all readers of KNOWLEDGE must appreciate the reproductions you have placed within their reach of these and Mr. Russell's photographs taken at Sydney.

I beg to offer you a few remarks on the history of the region, supplementary to those you have given. It does not appear that Halley, when he observed the star, noticed the nebulous matter adjacent to it, for it is not included in the list (only six in number) of nebulæ given by him in the *Philosophical Transactions* for 1716. So far as I am aware, Lacaille was the first to observe the nebula, which he describes in the *Mémoires de l'Académie des Sciences* for 1755. He gives three lists of star-clusters and nebulæ in the southern hemisphere, the third of which consists of "étoiles accompagnées de nébulosité." Of these, η Argûs is the sixth, thus described:—"Gros groupe d'un grand nombre de petites étoiles peu serrées, et remplissant l'espace d'une espèce de demi-cercle de 15 à 20 minutes de diamètre, avec une légère nébulosité répandue dans cet espace." After Lacaille, Dunlop appears to have been the first to observe this nebula, which he describes and figures in his catalogue of nebulæ and clusters formed from observations made at Paramatta in 1826–7, and published in the *Philosophical Transactions* for 1828. η Argûs is number 309 in his list, and he describes it as "a bright star of the third magnitude, surrounded by a multitude of small stars and pretty strong nebulosity, very similar in its nature to that in Orion, but not so bright. . . . The nebulosity is pretty strongly marked; that on the south side is very unequal in brightness, and the different portions of the nebulosity are completely detached, as represented in the figure. There is much nebulosity in this place, and very much extensive nebulosity throughout the Robur Caroli, which is also very rich in small stars." Not many years after Dunlop's observations Sir John Herschel made his famous astronomical expedition to the Cape. It is well known that he found that some of the objects set down as nebulæ by Dunlop had no real existence, the cause which misled him being probably want of sufficient light or defining power in his instrument. But to this I need not further allude. Those who have not access to Herschel's work on the results of his Cape observations will be grateful to you for the reproduction in KNOWLEDGE of his drawing of the grand nebula in η Argûs, now so beautifully brought before us in the photographs. But I scarcely think you will agree with Herschel in considering it probable that the nebulous matter is far beyond the stellar cluster, which forms a part of the Milky Way, for, apart from all other considerations, on that view how appallingly enormous would be its extent! May I ask whether the spectroscope has ever been applied to this region?

Yours faithfully,
Blackheath, May 12th, 1898. W. T. LYNN.

PHOSPHORESCENT METEORS.

To the Editor of KNOWLEDGE.

DEAR SIR,—Some twenty years ago I had an experience similar to that recorded from Thurso, in Prof. Tomlinson's paper in KNOWLEDGE.

I was staying the night with a friend. We sat up late, and when he had gone down to see that the house was safe, he returned rather promptly with the news that there was someone in the pantry, for he could see a light. Arming ourselves with the fire-irons, we crept downstairs.

The pantry was between the basement passage and the scullery, without external ventilation. As we turned towards the wire gauze door, the light was plain enough, rather bigger than a large open hand.

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Advancing cautiously, we found the light came from a sole that had been skinned, and was hanging from a shelf. It had been kept too long, and looked transparent, the bones showing distinctly brighter than the rest.

Not long since I saw a notice of some "luminous eggs," which probably were not very fresh.

Yours very truly,

THOS. BLASHILL,

Superintending Architect of the L. C. C.

29, Tavistock Square, W.C.

April 29th, 1893.

ON THE DISTRIBUTION OF THE STARS IN SPACE.*

By PROF. J. C. KAPTEYN.

PROF. KAPTEYN, of Groningen, read a preliminary paper on this subject on the 29th April last year. He has now included in the research all the stars of the Draper Catalogue, which have been observed by Bradley in both co-ordinates. This material embraces 2357 stars, of which 1189 belong to the *first*, 1106 to the *second*, and 62 to the *third* spectral type. The material now used permits more trustworthy conclusions than that of April, 1892, not only because it is more extensive, but chiefly because it is more homogeneous, and contains a very great number of smaller stars, possessing, nevertheless, trustworthy proper motions.

Before entering into a discussion of the results obtained, Prof. Kapteyn spoke upon the question of the best criterion for judging about the relative distances of the fixed stars. As the direct determination of stellar parallax has not as yet given results on anything like the scale wanted for the purpose, we are compelled to resort to the parallactic displacement caused by the motion of the solar system in space. This "motus parallacticus," however, cannot be separated from the real proper motion (*motus peculiaris*) for individual stars, but there is every reason to think that this "motus peculiaris" shows very little preference for determinate directions, and it may therefore be assumed, with some confidence, that, in the mean results obtained from small groups of stars, these real proper motions will destroy each other, leaving only that part which is due to the solar motion, and it is this parallactic displacement that, for the present at least, gives the most reliable measure of the mean distance of the stars under consideration. If, however, we wish to arrange the *individual* stars approximately in the order of their distances from the sun, we must look out for another measure. This may be found in the total proper motion. It is true that this motion seems only to be approximately proportional to the parallactic displacement (the researches of Ristenpart and of the speaker himself indicate a slow increase of the linear proper motion with the distance), but this is sufficient for the present purpose. There is another difficulty connected with the use of the total proper motion as a measure for distance, which may be very important in some cases. For if we compare by means of their total proper motion, *not* groups of stars which separately are distributed over the entire sky, but groups situated in different parts of the firmament, then a systematic error will be introduced, depending on the position with respect to the apex of the solar motion. For at the apex and anti-apex the whole proper motion is nothing but the *motus peculiaris*. At some distance from these points it is the resultant of the *motus peculiaris* and the *motus parallacticus*. Equality of total proper motion will not, therefore, correspond with equality of *motus peculiaris* in different parts of the sky, and it is highly improbable for that reason that even stars of absolutely equal distance would show equal proper motions in different parts of the sky.

Therefore this measure, too, fails for some detailed investigations of the star-system. In those cases where a systematic error from this source seemed most to be feared, Prof. Kapteyn used another measure, viz., that projection (τ) of the proper motion which is independent of the solar motion. As, however, this projection cannot be computed without a knowledge of the place of the solar apex, an assumption had to be made as to the position of this point.

The adopted co-ordinates for 1865 are :—

$$\alpha = 276^0. \qquad \delta = +34^0.$$

It was further assumed that the same co-ordinates would have been found by a separate discussion (*a*) of the stars *in* and *without* the Milky Way; (*b*) of the stars of the *first* and *second* spectral type.

The (at least approximate) truth of the first assumption had been proved by Mr. Bakhuyzen at the preceding meeting; the approximate truth of the second may be deduced from the fact that Messrs. Stumpe and Porter, and Ristenpart (12th March, 1893), found nearly the same position of the apex from stars of very different amounts of proper motion, a position tolerably accordant with that deduced exclusively from stars of smaller proper motion. As a matter of fact, however, we may say that the more the investigation is limited to stars of greater and greater proper motion, the more it is limited to stars of the second type. This will be proved in Proposition VI.

Having adopted the position of the apex as given, the total proper motions of all the Bradley-Draper stars were decomposed into two components, viz. :—

σ The proper motion projected on the great circle passing through the star and the apex.

τ The proper motion perpendicular to the former (which is evidently independent of the solar motion).

The results of Messrs. Porter and Stumpe prove indirectly for considerable proper motions, and for the sky as a whole, that the quantity τ is also a good measure for distance. *Directly*, it is proved by the consideration of the proper motions equal to or greater than 0″·04 of the Bradley-Draper stars; for, taking the means of the values of τ for stars of different amounts of proper motion, we find, if q be the mean value of the solar motion as seen at right angles from the stars under consideration :—

TABLE I.[1]

τ	q	Number of Stars.	Relative value of q.
0″·050	+0″·040	368	1
·150	+0·130	200	3·2
·450	+0·337	44	8·4

From this table it is evident, even for the smaller proper motion, that τ is nearly proportional to q, *i.e.*, nearly inversely proportional to the distance. The small discrepancy is in the sense found by Mr. Ristenpart.

It remains to be proved that, when we come to compare *different* regions of the sky, equality of μ, or better of τ, corresponds with equality of distance. Prof. Kapteyn tried to do this for regions of different galactic latitude, in the following way :—The small number of stars with proper motions exceeding 0″·50 being excluded, we find—

* Translated by Prof. Kapteyn from the Dutch report of his communication to the Amsterdam Academy of Sciences, 28th January, 1893.

[1] In Tables 1 and 2 the values of q furnished by stars whose distance from the apex is less than 40°, and which are necessarily very uncertain, have been omitted.

	1st Type.	2nd Type.
$\frac{\mu \text{ in high galactic latitude } (\pm 40^\circ \text{ to } \pm 90^\circ)}{\mu \text{ in low galactic latitude } (-30^\circ \text{ to } +30^\circ)}$	= 1·60	1·36
$\frac{q \text{ in high galactic latitude}}{q \text{ in low galactic latitude}}$	= 1·42	1·29

The agreement could not fairly be expected to be better. Somewhat less satisfactory is the comparison of the values of q and τ, as will be seen from Table 2.

Even here, however, the disagreement of the first two values of q may probably be explained by their probable errors (probable errors of each of these two values roughly $\pm$ 0″005).

TABLE 2 (1).

β (galact. latit.).	τ	q	Number of stars.
+ 40 to ± 90	0″050	+ 0″034	230
− 30 „ + 30	0·050	+ 0·050	138
± 40 „ + 90	0·150	+ 0·128	137
− 30 „ + 30	0·150	+ 0·133	63

Further investigations on this point must be deemed very desirable.

The proper motions were originally taken from Auwers's re-reduction of Bradley. A look at the proper motion τ, however, showed at once that a correction of the constant of precession (that of O. Struve) was necessary. This correction has been deduced by L. Struve, so that the proper motion σ and τ could be readily corrected. As this was done, however, after the completion of most of the computations, some of the results as given below are still based on the *uncorrected* proper motion. Where this is the case it will be explicitly mentioned.

After this introduction, the speaker discussed the following propositions.

Prop. I. If stars with very small or insensible proper motions are disregarded, there remains a group of stars showing no longer a condensation towards a plane (no Milky Way).

Prop. II. Stars with very small or insensible proper motions ($\leq$ 0″04) show condensation towards the plane of the Milky Way. This condensation exists as well for the stars of the 2nd as for those of the 1st type, so that in the arrangement of the stars of the 2nd type, too, there may be recognized an incontestable dependence on the position of the Galaxy. The condensation of the stars of the 1st type, however, is more considerable, and begins to be sensible for somewhat greater proper motions.

Prop. III. This condensation of stars of insensible proper motions is very considerable even for the brighter stars (0^m—$6^m{\cdot}5$). For stars of the 2nd type it is as considerable as for the whole of the stars of the ninth magnitude. For stars of the 1st type it is much more considerable.

Prop. IV. Either this condensation is at least partly *real* (*i.e.* not optically produced by greater depth), or there is *real* thinning out at the poles of the Milky Way.

Prop. V. The arrangement of the stars found by W. Struve has no real existence. The cause of the fallacy of his result lies in the fact that the mean distance of stars of determinate brightness *in* and *without* the Milky Way is not the same.

Prop. VI. (Compare communication of 29th April, 1892.) The nearest vicinity of the sun contains nearly exclusively stars of the 2nd type; with increasing distance the proportion Q of the number of stars of the 1st type to that of the 2nd grows gradually. Equality of number is reached at a distance corresponding to a total proper motion of 0″07. At still greater distances the stars of the 1st type begin to predominate very strongly.

(1) In Tables 1 and 2 the values of q furnished by stars whose distance from the apex is less than 40°, and which are necessarily very uncertain, have been omitted.

Prop. VII. It is exceedingly probable that (at least in the immediate vicinity of the sun) the variation of the value of Q must be attributed mostly to a real thronging of the stars of the 2nd type about a point not far from the sun, while the distribution of the stars of the 1st type is more nearly uniform (cluster of 2nd type stars).

Prop. VIII. The centre of greatest condensation of the stars of the 2nd type lies near the point of which the co-ordinates are

$$\alpha = 0\text{h. } 0. \qquad \delta = +42^\circ.$$

Prop. IX. This centre coincides nearly with the point which, according to the investigations and observations of Struve and Herschel, represents the apparent centre of the Milky Way (considered as a ring).

Prop. X. The stars of the first two spectral types are at equal distances if their mean total proper motion, or proper motion τ, is equal.

Prop. XI. The magnitude being equal, stars of the 1st type are in the mean 2·7 times more distant than those of the 2nd type. Or put in another way: The stars of the 1st type are in the mean seven times intrinsically brighter than those of the 2nd type.

The demonstration of Propositions I. to IV. was effected as follows:—

By parallels drawn for every 10 degrees of declination and by hour circles at different distances, the whole sky north of −30° of declination was divided into portions in such a way that every one of these contained only stars differing scarcely more than 10 degrees in galactic latitude. In every one of these portions the number of stars of determinate spectral type and determinate amount of proper motion was counted. Besides this the number of square degrees contained in every portion was computed, and the number of Bradley-Draper stars of magnitudes 0—6·5 contained in each such area was determined.*

After this, and after having united all the areas of equal galactic latitude, it was easy not only to determine the number of stars of different type and amount of proper motion at different distances from the Milky Way, but from these numbers could be further derived the values they would have assumed for 1000 square degrees and for the case that the material had embraced *all* stars of magnitudes 0—6·5.

The results of these countings and computations have been embodied in the two following tables:—

TABLE 3.—Arranged according to total proper motion. (μ).

I = 1st Type. II = 2nd Type. β = Galactic Latitude.

β Limits.	Me n.	μ = 0″60—0″03 I.	II.	0″04—0″05 I.	II.	0″06—0″07 I.	II.	0″08- 0″15 I.	II.	0″16 and higher. I.	II.
+ 60° to + 90°	69	18·6	14·9	9·6	12·7	8·5	14·3	17·0	13·8	6·4	28·7
+ 50 „ + 60	55	19·3	18·6	10·6	11·8	7·5	6·2	14·9	26·1	6·2	19·3
+ 40 „ + 50	45	24·6	15·8	8·4	9·9	7·9	6·4	15·3	23·7	6·4	22·7
+ 30 „ + 40	35	34·3	19·5	15·7	10·0	11·4	8·6	19·5	19·5	3·3	18·1
+ 20 „ + 30	25	48·1	27·8	26·2	14·4	8·0	6·9	19·8	20·3	4·8	20·8
+ 10 „ + 20	15	76·2	34·6	30·6	12·1	8·7	7·5	16·2	18·5	4·0	21·3
− 10 „ + 10	5	85·8	48·6	27·6	10·8	12·0	6·0	13·2	15·0	7·2	18·6

TABLE 4.†—Arranged according to the component τ of the proper motion.

β Limits.	Mean.	τ = 0″00—0″03 I.	II.	0″04—0″5 I.	II.	0″06—0″07 I.	II.	0″08—0″14 I.	II.	0″15 and higher. I.	II.
+ 60° to + 90°	69	29·2	31·9	15·9	9·0	5·3	8·5	5·8	15·4	3·7	19·6
+ 50 „ + 60	55	34·2	35·4	8·7	12·4	6·8	6·2	5·6	15·5	3·1	12·4
+ 40 „ + 50	45	36·5	33·5	11·3	11·8	3·9	6·9	6·9	10·4	3·9	15·8
+ 30 „ + 40	35	52·4	33·3	13·8	10·9	7·6	7·6	9·5	14·3	1·0	9·5
+ 20 „ + 30	25	65·1	46·5	18·7	14·4	13·9	6·9	8·0	11·7	1·1	10·7
+ 10 „ + 20	15	98·1	46·7	23·1	14·4	8·1	10·4	4·0	11·0	2·3	11·5
− 10 „ + 10	5	112·2	62·4	19·2	10·2	4·8	5·4	7·2	13·8	2·4	7·2

* This determination was made by aid of Seeliger's Tables.

† For this table the proper motions have been used *uncorrected* for L. Struve's alteration of the constant precession.

From Table 3 it is evident that a condensation towards the plane of the Milky Way begins to show itself for stars of the 1st type with proper motions 0″·04 – 0″·05; for stars of the 2nd type only in the stars of quite insensible proper motion (≦0″·03). For these, however, the condensation is not in the least dubious; it is as strong as the condensation of the whole of the stars of the ninth magnitude, and this proves conclusively that stars of this type are not arranged independently of the Milky Way, as might have been thought probable from the results obtained by Prof. Pickering ("Ann. of the Obs. of Harv. Coll.," Vol. 26, p. 462).

It is very easy to show that a systematic error in the estimation of the magnitudes of the stars in the Milky Way cannot change this result. It certainly is not improbable that such an error exists, and that this will prove sufficient to annul the slight *thinning* of the stars of the 2nd type with sensible proper motions in the vicinity of and in the Milky Way, but the condensation of the stars with insensible proper motions would then come out all the stronger.

Table 4 proves that these conclusions are independent of the motion of the solar system in space.

An attempt has been made to prove the truth of Prop. I. for fainter stars. The only fit material for such an investigation accessible to Prof. Kapteyn is furnished by the catalogue of stars of magnitudes 0—9·0 of L. Boss. The proper motions given in this catalogue, derived mainly from comparisons of the modern observations with those of Lalande and Bessel, were counted. If we assume that the number of these proper motions is incomplete to nearly the same extent as the zones of Bessel, we can derive the probable total number of the really existing proper motions. These have been given in the last two columns of the following table.

TABLE 5.

Distance from galaxy.	Number of square degrees.	Number of proper motions in Boss Catalogue.		Probable total number of proper motions.	
		0″·10–0″·20	≥0″·20	0″·10–0″·20	>0″·20
55° to 65°	390	46	39	76	65
39 „ 55	390	45	32	71	50
90 „ 39	390	41	29	73	53
−20 „ +20	390	35	15	72	31

For the proper motions 0″·10—0″·20, the uniformity leaves nothing to be desired. For the more considerable proper motions there appears to be a thinning out in the Milky Way. Prof. Kapteyn thinks that this thinning out is not to be considered as accidental, but that probably it is still only apparent. For if we assume a systematic error, of which the *sense* as well as the amount (0·2 mag.) is equal to that which Prof. Pickering really finds for the estimations of the Bradley-Draper stars in the Milky Way, this thinning out will be found to disappear.

Prop. IV.—The truth of this proposition, too, is proved by Table 3; for, as mentioned already, an unmistakable increase in the number of stars of the 1st type is visible for proper motions of 0″·04—0″·05, *i.e.*, within what probably is a spherical shell we find a smaller number of stars near the poles of the Milky Way than near that zone itself. This evidently implies a *real* difference in the star density.

Prop. V.—The incorrectness of Struve's views appears from Prop. I. Struve assumes, and in his time any other assumption would have been hardly reasonable, that the stars of different magnitudes are included between spherical surfaces, or, in other words, he assumed that in all directions the mean distance of stars of a determinate magnitude is equal. This appears to be incorrect, for Table 1 proves that, in the direction of the Milky Way a far greater number of stars of magnitudes 0—6·5 lie at the exterior of the sphere, the radius of which corresponds to a proper motion of 0″·035, than in the direction of the pole of the Milky Way; from which it follows that the mean distance of such stars is considerably greater in the Galaxy than elsewhere. It may, however, be objected against most of what has been said, that one cannot as yet consider it as absolutely demonstrated that equal distances correspond to equality of μ or τ *in* the Milky Way and *outside it*, and that if this proves ultimately not to be the case, the results drawn from Tables 3 and 4 cease to be correct. It will be well, therefore, to prove the truth of Prop. V. *directly*. For this purpose the values of q (solar motion as seen at right angles from star) in high and low galactic latitudes have been compared. Values of τ above 0″·50 have been excluded because they have an undue and excessive influence on the results.

TABLE 6.—Values of q.

β	Type I.	Type II.
± 40° to ± 90	+ 0″·0355 (336)	+ 0·0583 (449)
− 30 „ + 30	+ 0·0250 (405)	+ 0·0451 (285)

As the stars compared in both regions are of equal magnitude, it appears that for both types of stars there really exists a difference of distance at different galactic latitudes.

Prop. VI. was already discussed at the meeting of April, 1892. Then, however, the demonstration was almost exclusively based on the proper motions stars brought together by Mr. Stumpe. The stars now investigated confirm the conclusions of the preceding year in a most striking manner, as will be seen when the following table is compared with the one then given:—

TABLE 7.

μ Limits.	Mean.	Number of Stars. Type I.	Type II.	Q.
0″·00—0″·03		553	324	0·59
0·04—0·05	0″·045	233	150	0·64
0·06—0·07	0·065	118	104	0·88
0·08—0·09	0·085	85	90	1·06
0·10—0·15	0·12	130	162	1·25
0·16—0·19	0·17	29	61	2·1
0·20—0·29	0·24	25	86	3·4
0·30—0·49	0·37	13	71	5·5
0·50 and higher	1·02	3	58	19·3
		1189	1106	

The values of Q are nearly represented, with the exception of the first, by the formula:—

$$Q = 14\,\mu$$

especially if we exclude the Hyades, whereby the value of Q for the proper motions 0″·10—0″·15 becomes considerably larger.

It may be asked whether this variation of Q may be explained by the hypothesis that the stars of the 2nd type form a group of stars independent of that formed by the stars of the 1st type.

A definitive settling of this question seems difficult, but in the opinion of the speaker the following arguments seem to militate against such an hypothesis:—

1st. Both types of stars show the same sort of arrangement in respect to the plane of the Milky Way (Prop. II.).

2nd. The centre of condensation of the stars of the 2nd type seems to coincide with the centre of the Milky Way, which consists, in great part at least, of stars of the 1st type (Prop. IX.).

3rd. In groups of stars like that of the Hyades, which show a common proper motions (equal in amount as well

as in direction), and which therefore undoubtedly form a system, stars of both types appear to be mixed.

Provisionally it seems more probable to assume that the two types are different phases of evolution of stars pertaining to one and the same system. We then must assume that the temperature in this system increases from the centre towards the circumference. In harmony with this is the fact, communicated by the speaker at the meeting of 29th April, 1892, that the light of the stars of the Milky Way (*i.e.*, of stars in general more remote) seems to be richer in violet rays than the light of the rest of the stars.

It is a remarkable fact that in the group of the Hyades the *brightest* stars belong principally to the 2nd type, which for the rest is strongly in the minority in this group. This fact, together with Prop. XI., makes us conclude that these objects are by far the most bulky of the system. In this case, therefore, it is difficult to attribute the lower temperature to a more advanced state of cooling, so that, here at least, it seems more plausible to assume that the 2nd type stars are in a less advanced stage of evolution (rising temperature) than those of the 1st type. Whether this is the rule in the great system of the Milky Way seems very difficult to decide.

Prop. VII. If it is assumed that the distances are inversely proportional to the proper motion, it is easy to determine the relative volume of the spherical shells in which the stars with different proper motions are contained. The comparison of these volumes with the corresponding number of stars affords an insight into the real star density at different distances. In the following table the first column gives the limits of proper motion, the second the volume of the corresponding spherical shells. The following columns give the number of stars for unit of volume. As the numbers of the *different* columns are in no case comparable, they have been severally multiplied by such a number that the number corresponding to the proper motion 0″155—0″195 has become 1·0. If the distribution in space of the stars considered were uniform, then the numbers of each of the last four columns separately would be equal.

The third column was obtained by counting all the stars of the 1st type and of magnitudes 0·0—5·0, common to the catalogues of Stumpe (*Astr. Nach.* Nos. 2999—3000) and of Pickering (Draper Catalogue). The numbers of the fourth and sixth columns were furnished by the material Bradley-Draper; those of the last column but one were taken from Boss's zone catalogue. The number of stars belonging to the 1st type were computed in this case by taking the whole number of stars with proper motion ≧ 0″10, and assuming that for these stars, too, the values of Q from Table 7 were valid. At the foot of every column the number of stars is given on which the computation rests.

TABLE 8.—Number of Stars per unit of volume.

		Type I.			Type II.
μ	volume.	0m0—5m0.	0m0—6m5.	0m0—9m0.	0m0—6m5.
0″095—0″155	898·5		0·7	0·4	0·4
0·155—0·195	133·6	1·0	1·0	1·0	1·0
0·195—0·295	85·9	2·0	1·3	1·2	2·2
0·295—0·395	32·8				3·3
0·395—0·495	7·9	1·9	1·5	1·1	5·8
0·495—0·995	7·3				11·9
0·995 and higher	1·0				39·2
Total number of stars		46	200	(282)	438

If we confine ourselves to proper motions > 0″155, we see that the distribution of the stars of the 1st type approaches towards uniformity as we include more and more of the fainter stars in the discussion. On the other hand, we find the stars of the 2nd type with known proper motions more strongly condensed the more we approach our system. Now it may be that future extension of the available material will increase the number of small proper motions in a somewhat greater proportion than that of the more considerable proper motions; but it seems highly improbable that this will ensue to such a degree as to change the condensation implied in the last column into a uniform distribution. It can be shown, for instance, that even if all the stars which Herschel could see with his 16-inch reflector in high galactic latitudes furnished proper motions of 0″16—0″32 at the same rate as the stars of magnitudes 0—9·0 have done (which of course is an absurdly extreme supposition), even then one would *not* find the stars of this amount of proper motion equally condensed with the stars of proper motion exceeding 3″ known *at the present moment*.

It may be objected that the hypothesis adopted, viz., that the total proper motion is inversely proportional to distance, implies that the linear proper motion of the stars at different distances from the sun are equal, and that the investigations of Mr. Ristenpart ("Veröff der Grossh. Sternw. zu Karlsruhe," IV., p. 287) seem to point to a contrary conclusion. But it is easy to show that, Ristenpart's results being admitted (and those of the present author are confirmatory), our conclusion in respect to stars of the 2nd type is valid *à fortiori*. In this case, however, we should find the stars of the 1st type, too, somewhat condensed about the sun, though, of course, to an infinitely lesser degree.

Prop. VIII. At the meeting of 29th April, 1892, Prof. Kapteyn stated that the material afforded by the Stumpe-Draper catalogues pointed to the conclusion that the centre of greatest condensation of the stars of the 2nd type does not coincide with the position of the sun, but seems to be situate somewhere in the direction of 23 hours of R.A. This result was derived from a consideration of the quotient Q.

The Bradley-Draper material has been investigated to the same purpose in two different ways:—

1st. By the consideration of the quotient Q in different parts of the sky furnished by those stars whose proper motion $\tau \geqq 0''04$.

2nd. By the consideration of the number of stars of the 2nd type (for which $\tau \geqq 0''04$) that are found per 1000 square degrees in various parts of the sky. These numbers, reduced as formerly on the supposition that *all* stars of magnitudes 0 – 6·5 had been included in the investigation, are given in the last column of Table 9.

In both cases the sky was divided into thirteen regions, the limits of which are given in the first two columns:—

TABLE 9.[1]

Limits in δ.	Limits in α.	Q.	n.
−30° to + 20°	2h 36m — 2h 53m	1·88	48·9
,,	2·53 — 6·12	0·82	46·1
,,	6·12 — 9·46	0·89	43·7
,,	9·46 — 14·18	0·80	41·0
,,	14·18 — 16·54	0·71	39·0
,,	16·54 — 20·6	1·12	40·6
,,	20·6 — 23·6	0·93	39·3

The values of Q, contained in this table, have been corrected for a variation with the galactic latitude, which is not wholly insensible.

In the column of the Q, as well as in that of the n, the greatest values are found near 0h. of R.A. It is evident, therefore, that there is a certain region in the sky where the density of the 2nd type stars exceeds that of other

(1) In the computation of this table the *uncorrected* proper motions were used.

regions. If we assume that this density varies, from a certain point Ω of maximum density, in the same proportions as the cosine of the angular distance from this point, then we find by least squares for the co-ordinates A and D of the point Ω—

From the *Q*	A = 0h. 9	D = + 21°
,, *n*	A = 23·3	D = + 62
Adopted co-ord. of Ω	A = 0·0	D = + 42°

The galactic latitude of this point is − 20°.

The agreement of the two results, found by two different considerations, *inter se*, and with the result formerly derived from nearly totally different stars, speaks strongly for the reality of this centre of condensation.

The fact alluded to in the next proposition, noted by the speaker long after the above-given result had been arrived at, seems to speak not less clearly in its favour.

Sir J. Herschel, who, of all astronomers, was perhaps best acquainted with the aspect of the Milky Way in its whole course, says in his "Outlines of Astronomy," article 788, speaking of the Galaxy: "Throughout all this region its brightness is very striking, and when compared with that of its more northern course already traced, conveys strongly the impression of greater proximity, and would almost lead to a belief that our situation as spectators is separated on all sides by a considerable interval from the dense body of stars composing the Galaxy . . . . . within which we are excentrically situated, nearer to the southern than to the northern part of its circuit."

Prof. Kapteyn is not sure whether by "all this region" is meant the whole space from the middle between λ and γ Argûs (R.A. = 8h. 5m.) and α Centauri (R.A. = 14h. 5m.), or the more limited space between η Argûs (R.A. = 10h. 7m.) and the most southern point of the Galaxy (R.A. = 12h. 8m.). In both cases, however, the middle of this region lies near 11h. 6m. of R.A.

If, therefore, the Milky Way is to be considered as a ring, and according to what has been said, and to considerations of another order, there seems every reason for the inference, then the centre is probably to be sought in the direction of 23h. 6m. of R.A.

Further, according to the investigations of Struve, the sun is situated somewhat to the north of the plane of the Milky Way. The centre of the Milky Way, therefore, as seen from the sun, must have a small southern galactic latitude. The position of this centre agrees, therefore, with that found for the centre of condensation of the stars of the 2nd type, even within narrower limits than might have been expected.

Prop. X. The demonstration of this proposition is required in order to fully complete the demonstration of Prop. VI. It was attempted in several ways:—

a. The material Stumpe-Draper gave the results embodied in Table 10. Result:—

94 stars of Type I., mean total p.m. = μ 0″270, gave $q = +0''196$
325 ,, ,, II., ,, ,, reduced to $\mu = 0''270$, gave $q = +0''166$

b. The Bradley-Draper stars with proper motions μ = 0″08 and 0″09 gave:—

	Type I.	Type II.
Mean p.m. $\mu = 0''085$	$q = +0''056$ (112**)	$q = +0''041$ (77**)

c. (Stars of equal τ). All the Bradley-Draper stars, for which $\tau \geq 0''04$ (Type I.), or between 0″04 and 0″29 (Type II.). Only the stars of which the galactic latitude is between ± 30° and ± 40° were disregarded.*

* These were only omitted for the practical reason that they would have had to be computed on purpose, whereas the rest served already for Table 1.

TABLE 11.

d. Stars of known spectrum and of which tolerably trustworthy parallaxes have been determined:—

	Mean value of μ.	Mean Mag.	Mean π.	Number of Stars.
Type I. ...	1″60	2·8	0″159	7
,, II. ...	1″64	3·6	0″137	19

Prop. XI.—Table 12 was obtained by bringing together all the Bradley-Draper stars, with the exception only of those stars of the second type of which the spectrum is marked with ? in the Draper Catalogue.

TABLE 12.†

	Mag.	Mean Mag.	τ	μ	q	Number of Stars.
Type I.	0·0—2·9	2·14	0″147	—0″012	+0″111	46
,,	3·0—3·9	3·35	0·086	—0·023	+0·062	78
,,	4·0—4·9	4·39	0·061	—0·010	+0·031	182
,,	5·0—5·9	5·37	0·054	—0·013	+0·031	417
,,	6·0— ...	6·27	0·053	—0·019	+0·027	465
Type II.	0·0—2·9	2·07	0·347	+0·026	+0·350	23
,,	3·0—3·9	3·35	0·295	—0·020	+0·137	62
,,	4·0—4·9	4·41	0·176	—0·050	+0·096	129
,,	5·0—5·9	5·39	0·143	—0·007	+0·092	322
,,	6·0— ...	6·24	0·120	—0·013	+0·069	326

From this table, Table 13 was derived by simple interpolation.

TABLE 13. Values of q.

Mag.	Type I.	Type II.	q^{II}/q^{I}
2·3	+0″105	+0″312	3·0 (½)
3·3	+0·064	+0·145	2·3
4·3	+0·034	+0·100	2·9
5·3	+0·031	+0·092	3·0
6·3	+0·027	+0·067	2·5
		Mean	2·7

By this table the first part of the proposition is demonstrated. If now we imagine the stars of the first type brought down to the same distance from the sun as those of the second type, then the brightness of the former will be $(2·7)^2 = 7·3$ times as considerable as that of the latter, q. e. d.

† In computing this table the *uncorrected* proper motions have served.

THE FACE OF THE SKY FOR JUNE.

By HERBERT SADLER, F.R.A.S.

THE abnormal activity of the Sun still continues. Throughout the month there is no real night, but either daylight or twilight.

Mercury is in superior conjunction with the Sun on the 5th. On the 15th he sets at 9h. 23m. P.M., or 1h. 7m. after sunset, with a northern declination of 25° 10′, and an apparent diameter of 5½″, $\frac{88}{100}$ths of the disc being illuminated. On the 25th he sets at 9h. 44m. P.M., or 1h. 26m. after the Sun, with a northern declination of 22° 53′, and an apparent diameter of 6″, $\frac{69}{100}$ths of the disc being illuminated. On the 30th he sets at 9h. 45m. P.M., or 1h. 27m. after the Sun, with a northern declination of 20° 50′, and an apparent diameter of 6½″, $\frac{60}{100}$ths of the disc being illuminated. While visible he passes through part of Gemini into Cancer. He is near Venus on the 15th.

Venus is visible as an evening star after about the middle of the month. She sets on the 15th at 9h. 14m. P.M., or 58m. after sunset, with a northern declination of 24° 11′, and an apparent diameter of 10″, $\frac{98}{100}$ths of the disc being illuminated. On the 30th she sets at 9h. 23m. P.M., with a northern declination of 22° 28′, and an apparent

diameter of $10\frac{1}{4}''$, $\frac{96}{100}$ths of the disc being illuminated. While visible she describes a direct path in Gemini.

Mars, Jupiter, and Neptune are invisible for the purposes of the amateur.

Saturn is an evening star, and is still well situated for observation. He rises on the 1st at 1h. 45m. P.M., with a southern declination of 0° 3′, and an apparent equatorial diameter of $17\frac{3}{4}''$ (the major axis of the ring system being 41″ in diameter, and the minor 4·4″). On the 15th he rises at 0h. 46m. P.M., with a southern declination of 0° 6′, and an apparent equatorial diameter of $17\frac{1}{2}''$ (the major axis of the ring system being 40″ in diameter, and the minor 4·3″). On the 30th he sets 6m. before midnight, with a southern declination of 0° 18′, and an apparent equatorial diameter of 17″ (the major axis of the ring system being 39″ in diameter, and the minor 4·3″). He is occulted by the Moon on the 21st, but the phenomenon will only be visible in the southern hemisphere. Rhea is in superior conjunction at 7·5h. P.M. on the 7th; in inferior conjunction at 1·7h. A.M. on the 10th; Iapetus is in inferior conjunction on the 11th; Rhea is in superior conjunction at 8·4h. P.M. on the 16th, and at 9·3h. P.M. on the 25th. Iapetus is at his greatest western elongation on the 30th. A map of the path of Saturn during June will be found in the "Face of the Sky" for March.

Uranus is also an evening star, and but for his southern declination would be favourably placed for observation. He rises at 4h. 45m. P.M., on the 1st, with a southern declination of 13° 34′, and an apparent diameter of 3·7″, On the 30th he rises at 2h. 47m. P.M., with a southern declination of 13° 21′. A map of his path during June will be found in the "Face of the Sky" for April.

There are no very well-marked showers of shooting stars in June.

The Moon enters her last quarter at 1h 43m. P.M. on the 7th; is new at 5h. 51m. P.M. on the 14th; enters her first quarter at 2h. 37m. A.M. on the 21st; and is full at 6h. 25m. A.M. on the 29th. She is in perigee at 5h. P.M. on the 13th (distance from the earth 222,280 miles), and in apogee at 2h. P.M. on the 26th (distance from the earth 252,230 miles).

Chess Column.

By C. D. Locock, B.A.Oxon.

All communications for this column should be addressed to the "Chess Editor, *Knowledge Office*," and posted before the 10th of each month.

Solution of May Problem (G. K. Ansell) :—

1. Q to Kt8, and mates next move.

Correct Solutions received from H. S. Brandreth, R. B. Cooke, E. M. Jones, and one unsigned (postmark illegible).

A. G. Newberry.—After 1. P to QB4, Black moves (anything), there is no mate, the King escaping at B6 in reply to Q to B2ch.

In the problem which you send you mention both a Queen and a Rook as being on KKtsq.

R. B. Cooke.—Very glad to hear that after so many years you have succumbed to the temptation of sending in a solution.

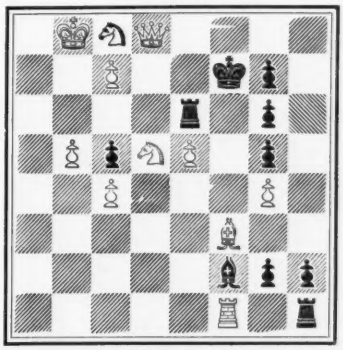
A. S. Fellows.—The problem is very pretty, and is marked for insertion in the August number.

J. F. Welsh.—Thanks for the game. It is a little short for publication in a one game monthly column. White's 20th move is a surprising stroke.

PROBLEM.

By S. Loyd.

Black.



White.

White to play, and mate in three moves.

[In the above problem, "the main idea is expressed in the defence." The bearing of this observation lies in the application of it, and will come as a revelation to those who at first perceive a plurality of key-moves.]

The following game was played in the recent match at Kokomo, Ind. :—

Irregular Opening.

White (E. Lasker).	Black (J. W. Showalter).
1. Kt to KB3	1. P to Q4.
2. P to Q4	2. Kt to KB3
3. P to K3	3. P to K3
4. B to Q3	4. P to QKt3 (*a*)
5. QKt to Q2 (*b*)	5. B to Kt2
6. Kt to K5	6. B to Q3
7. P to KB4 (*c*)	7. Castles ?
8. Q to B3 ! (*d*)	8. P to B4
9. P to B3 (*e*)	9. Q to B2 (*f*)
10. P to KKt4	10. Kt to Ksq (*g*)
11. Q to R3	11. P to Kt3
12. P to Kt5 ! (*h*)	12. B × Kt (*i*)
13. BP × B	13. Kt to Kt2
14. R to KKtsq	14. Kt to Q2
15. Kt to B3 (*j*)	15. KR to Ksq (*k*)
16. B to Q2	16. P to QR3 (*l*)
17. Q to Bsq (*m*)	17. P to Kt4
18. P to KR4	18. P to B5
19. B to B2 (*n*)	19. KR to KBsq ?
20. Q to R3	20. P to QR4
21. Kt to R2	21. P to Kt5 (*o*)
22. Kt to Kt4	22. P to Kt6 ?
23. B to Qsq	23. Kt to KB4 (*p*)
24. P to R5	24. K to Kt2
25. Kt to B6	25. R to Rsq
26. B to Kt4 (*q*)	26. Kt to K2 ? (*r*)
27. B × P !	27. Kt × P
28. P × Kt	28. P × B
29. Q × P	29. R to R3 (*s*)
30. P to R6ch	30. K to Bsq
31. Q to Q7	31. Q × Q
32. Kt × Qch	32. K to Ksq
33. Kt to B5	33. R to R2
34. P × P	34. P × P
35. R to KBsq	35. B to B3
36. Kt × P	36. P to R5
37. Kt to Q4	37. R to Bsq
38. R to B6	38. B to Q2
39. P to K6	39. B to Bsq
40. Kt to Kt5	40. Resigns.

XUM

NOTES.

(*a*) P to B4 is more forcible now than at any other time.

(*b*) In accordance with the modern fashion, which is to play these close games on the King's side. Zukertort's method consisted in castling at once and devoting his attention entirely to the advance of the Pawns on the Queen's wing.

(*c*) Though contrary to theory, inasmuch as the King's Pawn is left weak, this move has stood the test of recent practical play. Black's reply is certainly premature, though he cannot play 7. . . B × Kt, 8. BP × B, KtK5; 9. B × Kt, P × B; 10. Q to Kt4, winning a Pawn.

(*d*) A fine move, preventing Kt to K5, and therefore giving additional force to the threatened advance of the KKtP. Perhaps Black's best reply under the circumstances was B to R3.

(*e*) Hardly necessary, as Black cannot play P to B5; but possibly he was providing against B to R3.

(*f*) Quite useless. Better would have been 9. . . Kt to Ksq, followed by P to B4 or B3 according to circumstances.

(*g*) Now, however, he should move the Rook, in order to make room for either Knight or Bishop at KBsq, according to requirements.

(*h*) To prevent P to B3; threatening also Kt to Kt4 in due time.

(*i*) He might play 12. . . Q to K2, with a view to B × Kt or P to B3. The alternative was 12. . . Kt to B3.

(*j*) Chiefly, no doubt, to prevent Black from freeing his game by Kt × P. In any case 15. R to Kt4 was useless, as (apart from the reply 15. . . . Kt × P) Black could defend himself by 15. . . . KR to Ksq; 16. R to R4, Kt to Bsq, &c.

(*k*) This might wait till White plays R to Kt4, as in the previous note.

(*l*) If he intends ultimately to play P to B5, he might as well do so at once, and follow it by P to Kt4, saving a move.

(*m*) In order to advance the KRP, and thereby allow the Knight to play to KKt4 *viâ* KR2.

(*n*) There is something to be said too for B to K2 with a view to Kt to R2 and P to R5 (or P to R5 at once if Black reply Kt to KB4). Black's next move is quite unintelligible.

(*o*) Now perhaps Kt × P would have given him chances of breaking through on the Queen's side, but it would be at the cost of exchanging Queens. His next move is very questionable, as it ultimately gives White the open Rook's file. P × P would be better.

(*p*) With a view to his next two moves, which lead to the shutting out of the Rook; but as White in any case threatens Kt to B6ch and P to R5, it does not appear that he has anything better to do. The position is against him, his pieces being hopelessly shut out from the King's side.

(*q*) P to R6ch first would be better—*vide* note (*r*).

(*r*) An oversight. 26. . . . P to R3 should be played at all hazards.

(*s*) There is nothing else to be done in view of the threatened P to R6ch and R to KBsq. After the exchange of Queens, which is forced, the remainder plays itself. Mr. Lasker conducted the whole game with his usual ability.

CHESS INTELLIGENCE.

Mr. Lasker recently defeated Mr. Showalter, the Kentucky Champion, in a match by six games to two, with two draws. By mutual agreement the three games of the previous abandoned match, in which each player won one game, the third being drawn, were included in the score of the later match. It is rumoured that Mr. Lasker intends to challenge Mr. Steinitz to a match for 5000 dollars, and the championship of the world. Mr. Steinitz remarks that a challenge for such a sum would be "entitled to respect," provided that the other conditions are equally fair.

Herr Walbrodt has won a match from Mr. Delmar by five games to three, with three draws. The deciding game should have been won by Mr. Delmar, who threw it away in the end game. The result of the match, with which Mr. Delmar is not satisfied, seems to show that Herr Walbrodt was either out of form or is not so difficult to beat as has generally been supposed.

The death is announced of Jean Dufresne, the opponent of Anderssen, and at one time editor of the *Schachzeitung*. He was the author of the *Lehrbuch des Schachspiels*.

C. Salvioli is now the editor of the *Nuova Rivista degli Scacchi*, the Italian chess monthly. He is well known as the leading Italian player and analyst. The May number contains an entertaining article on "Chess Knight-errants," with reference especially to Lasker and Walbrodt, and the consternation of the former on landing at Havana at finding Herr Walbrodt in possession of the soil which he (Herr Lasker) "had proposed to himself to cultivate." The following is a pretty two-move problem by G. B. Valle, from a former number:—*White*: K at KR8, Q at QR5, R at K4, B at KR5, Pawns at KKt3 and Q2. *Black*: K at Q6, Rooks at KR7 and QB8, Pawns at KR5 K4, QB4, and QB7. White mates in two moves. Solutions will be acknowledged.

On May 13th Surrey defeated a weak Sussex team at Croydon by eleven games to six. The previous match resulted in a tie.

A match of seven games up is now in progress at Simpson's Divan, between Messrs. Bird and Jasnagrodsky. The present score is Bird 3, Jasnagrodsky 2.

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